MARYLAND BIOLOGICAL STREAM SURVEY
2000-2004

Volume IX

Aquatic Biodiversity

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

CHESAPEAKE BAY AND
WATERSHED PROGRAMS
MONITORING AND
NON-TIDAL ASSESSMENT
CBWP-MANTA-EA-05-6

Robert L. Ehrlich, Jr.
Governor

Michael S. Steele
Lt. Governor

A message to Maryland's citizens

The Maryland Department of Natural Resources (DNR) seeks to preserve, protect and enhance the living resources of the state. Working in partnership with the citizens of Maryland, this worthwhile goal will become a reality. This publication provides information that will increase your understanding of how DNR strives to reach that goal through its many diverse programs.

C. Ronald Franks
Secretary

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Tawes State Office Building
580 Taylor Avenue
Annapolis, Maryland 21401

Toll free in Maryland: 1-(877)- 620-8DNR ext. 8610
Out of state call: 410-260-8610
TTY via Maryland Relay: 711 (within MD)
800-735-2258 (out of state)
www.dnr.maryland.gov

THE FACILITIES AND SERVICES OF THE MARYLAND DEPARTMENT OF NATURAL RESOURCES ARE AVAILABLE TO ALL WITHOUT REGARD TO RACE, COLOR, RELIGION, SEX, SEXUAL ORIENTATION, AGE, NATIONAL ORIGIN, OR PHYSICAL OR MENTAL DISABILITY.

This document is available in alternative format upon request from a qualified individual with a disability.

Publication # DNR-12-0305-0106

Published July 2005

PRINTED ON RECYCLED PAPER

Maryland Biological Stream Survey
2000-2004

Volume 9:
Stream and Riverine Biodiversity

Prepared for

Maryland Department of Natural Resources
Monitoring and Non-tidal Assessment Division
Tawes State Office Building
580 Taylor Avenue
Annapolis, Maryland 21401

Prepared by

Paul F. Kazyak
Jay V. Kilian
Scott A. Stranko
Martin K. Hurd
Daniel M. Boward
Christopher J. Millard
Ann Schenk

Maryland Department of Natural Resources
Tawes State Office building
580 Taylor Avenue
Annapolis, Maryland 21401

July 2005

PUB # DNR 12-0305-0106
EA-05-6

FOREWORD

This report, *Maryland Biological Stream Survey 2000-2004 Volume 9: Stream and Riverine Biodiversity*, was prepared by staff from the Maryland Department of Natural Resources' Monitoring and Non-Tidal Assessment Division. It was supported in part by Maryland's Power Plant Research Program (PPRP Contract No. K00B020019 to Versar, Inc.). Portions of this report were also supported by grants from the United States Fish and Wildlife Service via the State Wildlife Grant program; facilitated through Memoranda of Understanding between the Natural Heritage Program and the Monitoring and Non-tidal Assessment Division, Ecological Assessment Program.

ACKNOWLEDGMENTS

Literally all aspects of the Maryland Biological Stream Survey have been a cooperative effort among Maryland DNR, several academic institutions, and consulting firms, as listed in the Acknowledgments sections of Volumes 1-5 of this report. The multitude of dedicated staff involved in field collection, data entry and management, and other MBSS activities has been key to the overall continued success of the program.

For this volume, the authors would also like to acknowledge the contributions of the following individuals who contributed data analyses, graphical support, editing, or other talents specific to this volume:

Versar	**DNR**
Mark Southerland	Ann Roseberry Lincoln
Ginny Rogers	Jason Ladell
Allison Brindley	Heather Lhamon
Sherian George	Brian Moody
Jon Vølstad	
Ed Weber	

We would also like to thank Richard Raesly, Mark Southerland, Gwen Brewer, and Robert Hughes, and Joel Snodgrass for serving as external peer reviewers for this volume.

ABSTRACT

One of the most important potential uses of the Maryland Biological Stream Survey (MBSS) is to support stream and riverine biodiversity management in the State. Recognizing this importance, this volume was prepared to highlight biodiversity findings from the MBSS as well as other sources and to contribute to DNR's Wildlife Diversity Conservation Plan for conserving non-game species in Maryland. More than 2,500 quantitative MBSS sites and other qualitative data were assembled and assessed to provide one of the most detailed, broad-scale accounts of freshwater biodiversity and associated habitats available in the United States. Although the database was extensive, significant knowledge gaps and monitoring needs exist, including the need for a better understanding of life history, fine-scale distribution, migration and connectivity requirements of many taxa. There is also a need for genetics and species-specific stressors data for most Maryland taxa. There are about 91 million freshwater fishes in Maryland streams. Of the 77 species native to some part of Maryland that spend a considerable portion of their time in freshwater, 19 have very low overall populations or are contained in very small geographic areas and thus are at risk from catastrophic events. Even widely distributed fish species are at risk in some watersheds because of isolation and small population size. Biodiversity assessments revealed that stream herpetofauna, especially stream salamanders, are sensitive to many types of human disturbance. Similar findings were documented for fishes and benthic macroinvertebrates. Given the statewide or regional scope of many of these threats, continuation or expansion of these threats will likely have a profound negative effect on aquatic biodiversity in the future. In particular, introduction and expansion of non-native species and expansion of impervious surfaces represent important, growing threats to Maryland's freshwater biodiversity. A tiered ranking scheme for 8 digit watersheds in Maryland was developed that included consideration of strongholds for rare species, conservation of all native species, rarity of species, assemblage intactness/biotic integrity, and use by migratory fishes. Using this approach, Zekiah Swamp, Deer Creek, Casselman River, Youghiogheny River, and Corsica River/Southeast Creek watersheds had the highest aquatic biodiversity ratings in Maryland. The lowest ranking watersheds in the state for aquatic biodiversity were the Catoctin Creek, Georges Creek, Potomac River-Frederick County, West Chesapeake, and Back River watersheds. Twenty-five (25) of 84 watersheds were strongholds for at least one state-listed stream or riverine species, and all but two watersheds contained unique benthic macroinvertebrate fauna. Finally, every watershed in Maryland contained at least one GCN species. In total, the ranking exercise clearly identified that aquatic biodiversity protection is warranted on a widespread basis so that ecosystem goods and services can be maintained and ultimately improved for the benefit of the state's citizenry. Given this fact, focusing on public lands alone will be insufficient to protect aquatic biodiversity in Maryland. Current Chesapeake Bay and Coastal Bays restoration and protection efforts provide a unique opportunity for freshwater biodiversity conservation. In the Maryland portions of these ecosystems, it may be appropriate to target waters inhabited by rare or imperiled species to benefit both freshwater biodiversity and estuarine health. To aid in that process, threats to freshwater biodiversity were ranked by watershed, and conservation actions were linked to those threats to provide managers with a list of possible beneficial actions.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

Table No. **Page**

LIST OF FIGURES

Figure No. **Page**

LIST OF FIGURES (CONTINUED)

Figure No. **Page**

9.1 INTRODUCTION

This volume on freshwater biodiversity is part of a series of related documents that summarize findings of the Maryland Biological Stream Survey (MBSS). Most volumes in the series use data from the 2000-2004 Survey. However, some documents, including this volume, utilize data from 1994 to 2004 and incorporate data from other sources as well. The audience for this volume includes all those who have an interest in freshwater biodiversity in Maryland. The objectives of the volume are to:

- Provide an overview of aquatic biodiversity management efforts in Maryland;
- Describe, based primarily on findings from the MBSS, the status of fishes, aquatic herpetofauna, and benthic macroinvertebrate biodiversity in Maryland streams and rivers;
- Provide information useful to the management of aquatic species of Greatest Conservation Need (GCN) in Maryland;
- Provide a ranking of Maryland watersheds in terms of aquatic biodiversity;
- Identify threats to aquatic biodiversity in Maryland, by watershed and by GCN species; and
- Identify appropriate conservation actions to ensure that aquatic biodiversity in Maryland is protected and, where appropriate, restored.

On a global scale, human disturbance has elevated the extinction rate for species to 1,000-10,000 times greater than natural levels (Kellert and Wilson 1993). Unchecked, this loss of biodiversity will ultimately threaten human survival (Chapin et al. 2000). Considering this, and the fact that freshwater organisms are in peril nearly everywhere (Braun et al. 2000) and consistently rank as

WHO CAN USE THIS DOCUMENT:

Citizens- to better understand and provide input on conservation initiatives

Landowners- to make informed decisions about long-term conservation on their property

Local Governments- to incorporate sound, targeted conservation practices, policies, and zoning

Watershed Associations- to consider biodiversity as they work to protect water resources

Land Trusts- to help prioritize and manage lands for living resource value and functioning ecosystems

Conservation Organizations- to stimulate science-based strategies for conserving natural resources

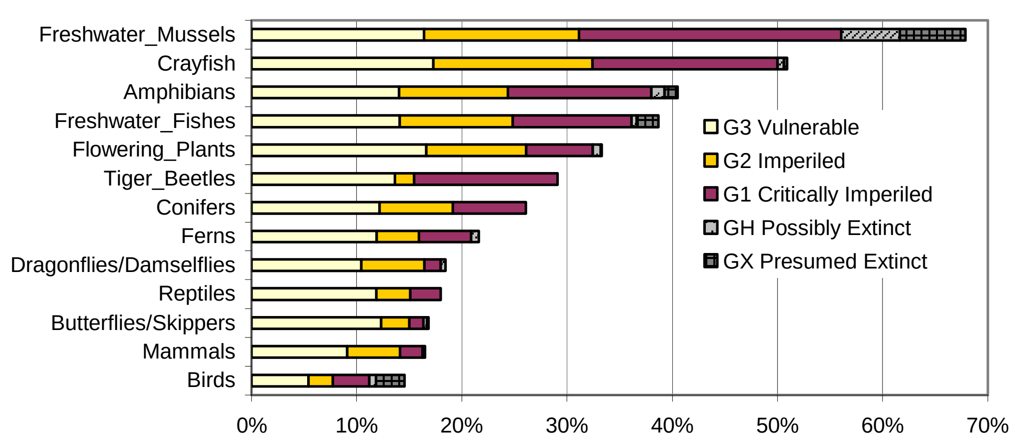
Maryland State Government- to make science-based ecosystem management decisions and maintain or improve environmental quality

Federal Government- to justify funding allocations for Maryland conservation efforts, design and implement regional conservation plans, and better manage Federally owned lands in Maryland

Educational Institutions- to provide a conservation education tool

Academics- to direct future research

The most at-risk groups of plants and animals in the United States are freshwater mussels, crayfish, amphibians, and freshwater fishes.



Percentage of species extinct or endangered in selected categories. (from: TNC 1997; http://conserveonline.org/2001/06/t/en/report.pdf) more threatened than terrestrial forms (Allen and Flecker 1993; Ricciardi and Rasmussen 1999), there should be no shortage of interest in freshwater biodiversity management. We hope policymakers, planners, and others will use the information contained here to help justify and direct freshwater biodiversity conservation and restoration efforts in Maryland. In particular, we believe that existing and planned restoration, protection, and mitigation efforts such as the Chesapeake Bay clean-up should incorporate freshwater biodiversity management as an important part of the targeting process.

9.1.1 The Physical and Chemical Template

Freshwater biodiversity in Maryland has been largely shaped by its geologic history, climate, physiography, geology and soils, and human landscape influences. Most streams in Maryland were once part of the ancient Susquehanna River network, with some of the western portion of the state forming part of the Mississippi drainage. Glaciation never extended as far south as Maryland, and consequently there are no natural lakes in the state. However, the climate influence of glaciation likely played a key role in creating a coldwater environment in which fewer species could persist. This is evidenced by the fact that Maryland has fewer freshwater fish species than neighboring Virginia (Jenkins and Burkhead 1993; Lee et al. 1981), although it has a similarly high diversity of aquatic habitat types. Glaciation also lowered sea levels and allowed connections between now isolated river mouths. More recently, human influences have played and continue to play a key role in the distribution and abundance of freshwater species. A more extensive treatment of the environmental setting for Maryland streams and its influence on biota can be found in Roth et al. (1999). This document can be downloaded from www.dnr. maryland.gov/streams/pubs/ ea-99-6.pdf.

When considering freshwater biodiversity in Maryland, it is important to note that the environmental setting for streams and rivers is changing at a relatively rapid pace. Based on Maryland Department of Planning data, this change has been profound. The amount of land in Maryland converted to urban uses between 1994 (when the MBSS began as a demonstration project) and 2002 (midway through the second round of sampling) equaled the size of Prince Georges and Montgomery Counties combined (approximately 1000 square miles). Since 2002, many additional square miles of land have been converted from agriculture and forests to urban area. Previous and current analysis of MBSS data (Roth et al. 1999; Volume 14 this report) established a clear, negative relationship between biotic integrity and the amount of imperviousness in the upstream catchment, with obvious response signatures even at low levels of imperviousness. Clearly, the additional development currently occurring and forecasted for the future will have profound adverse effects on freshwater biodiversity in Maryland.

9.1.2 Importance of Freshwater Biodiversity

Freshwater biodiversity in Maryland is important to its citizens. In addition to providing sources of food, freshwater biodiversity provides other needed goods and services such as energy processing, efficient recycling of waste from humans, mosquito control, water purification, retention of excess nutrients and sediment, climate moderation, detoxification of many contaminants moderation of natural hazards such as flooding, high quality living classrooms for education, novel products such as jewelry from stream insect cases, recreation and tourism, and cultural values. In many cases, these attributes play a direct role in human health and influence our quality of life as well. Because of the variety of life in streams and rivers, these ecosystems also provide resiliency in the face of disease outbreaks, floods, drought, and shifts in climate.

DEFINITION OF BIODIVERSITY: LIBRARY OF LIFE

A commonly accepted definition of biodiversity is …the variety of life and its processes. It includes the variety of organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning, yet ever changing and adapting (Noss and Cooperrider 1994). From a human-centric perspective, it contains the parts necessary to provide goods and services necessary for human existence. Some components of biodiversity such as pollution-sensitive species serve as early warning signals of declining environmental conditions.

Biodiversity can be described at multiple scales, including genetic, species, ecosystem, and landscape levels. The MBSS is best able to provide information about species and ecosystems in Maryland. At present, genetic diversity information is only available for a few freshwater taxa. These include sculpins (Neely 1999; Kinziger et al. 2000), logperch (George 2005), and brook trout (Baker and Morgan 1991; Danzmann et al. 1998; Morgan and Danzmann 2001; Hall et al. 2002).

The replacement cost for providing these goods and services would dwarf the cost of preserving what currently exists. For example, Daily and Ellison (2002) reported that New York City is spending more than $1.5 billion in watershed protection and management activities to maintain the high quality of their drinking water. This number is at least four-fold less expensive than the alternative of a mechanical filtration plant, and is aprotecting aquatic biodiversity. Worldwide, the monetary value of ecosystem services and natural capital has been conservatively estimated at $33 trillion per year; nearly twice the global gross national product (Constanza et al. 1997). Unfortunately, the considerable value of ecosystem services and biodiversity is typically not accounted for in economic assessments. Beyond the economic value of aquatic biodiversity, many citizens recognize the responsibility to pass on to future generations an environment that is at least as good as the one they inherited.

POTENTIAL ECONOMIC VALUE OF FRESHWATER BIODIVERSITY

A number of commercially valuable species of fish in Maryland spend a portion of their lives in non-tidal streams and rivers. These species include American eel, American shad, hickory shad, blueback herring, alewife, yellow perch, white catfish, and brown bullhead. If the peak historical harvests for these species were combined (Krathamer and Richkus 1987; Richkus et al. 1994; Foster 1995; Sauls *et al*. 1998), they would total more than 75 million pounds. Assuming a dockside value of $0.50 per/lb, the direct commercial value of these species would be on the order of $37 million. In the last several decades, commercial harvest of most of these species has declined or been eliminated as a result of migration barriers, habitat destruction, and other problems.

Overall, human disturbance of streams and rivers in Maryland has been profound. It is unlikely that the species richness and biomass of pre-Columbian biotic communities will ever be approached, but much value remains and needs to be adequately protectedto ensure our economic health, quality of life, and inheritance for future generations of Marylanders.

To keep every cog and wheel is the first precaution of intelligent tinkering. *Aldo Leopold*

9.1.3 Roadmap to this Volume

The remaining chapters in this volume are arranged by topic, beginning with fishes, and followed by stream herpetofauna, benthic macroinvertebrates, high and low integrity streams, watershed ranking, non-native aquatic species, and maintaining biodiversity. This volume also has an appendix that presents information on GCN fish species (Appendix A, as defined in Maryland's Wildlife Diversity Conservation Plan (in prep; http://www.dnr.state.md.us/wildlife/wldivplan.asp). Appendix B summarizes the status, threats and applicable conservation actions for amphibian GCN species, while Appendix C provides additional supporting information on benthic macroinvertebrates. Finally, Appendix D provides a list of biodiversity threats for each of the watersheds in Maryland. To limit the size and complexity of this volume and increase readability, all methods used to prepare and analyze data for this volume are presented in 2000-2004 Maryland Biological Stream Survey Volume 6: Laboratory, Field, and Analytical Methods. This volume can be downloaded from http://www.dnr.Maryland.gov/streams/pubs/ea05-n_method.pdf. Within this report series, other volumes that contain information and synthesis pertaining to aquatic biodiversity and its management include

2000-2004 Maryland Biological Stream Survey Volume 8: County Results. This volume contains watershed ranking maps of freshwater biodiversity for each county, with stream reaches of greatest interest highlighted. Download from http://www.dnr.maryland.gov/streams/pubs/ea05-5_county.pdf.

2000-2004 Maryland Biological Stream Survey Volume 10: Riparian Zone Conditions. This volume contains information and graphics pertaining to the distribution and relative abundance of invasive plants found in riparian zones and floodplains. Download from http://www.dnr.Maryland.gov/streams/pubs/ea05-7_riparian.pdf.

2000-2004 Maryland Biological Stream Survey Volume 14: Stressors. This volume contains information about threats to freshwater biodiversity in Maryland. Download from http://www.dnr.maryland.gov/streams/pubs/ea05-11_stressor.pdf.

9.2 BIODIVERSITY MANAGEMENT IN MARYLAND

9.2.1 Historical View

As in other areas of the country, natural resource conservation did not play an important role early in Maryland's history. As a result of several hundred years of logging, there are no streams in Maryland that approximate conditions found in an undisturbed or pristine state. Large woody debris and rootwads, two important habitat components of streams, are greatly reduced in abundance even compared to levels (Roth et al. 1999). There are well over 1000 documented barriers to migratory fishes in Maryland (DNR, unpubl. data), and based on the number of road crossings of streams alone, an equal or greater number of migration barriers for resident fishes have not been documented.

When the cumulative effects of logging, overexploitation, dam construction, agriculture and other activities reduced the quality of recreational fishing in the late 1800s, the primary response was to stock non-native species (most often reared in hatcheries) as replacements for native biota. With the dawn of the environmental movement in the late 1960s and early 1970s, legislation such as the

Federal Water Pollution Control Act (and its successor, the Clean Water Act) focused attention on water quality, but little attention was placed on biological integrity as prescribed in the enabling legislation. In the mid-1970s, Maryland implemented a CORE/TRENDS monitoring network for water quality (http://www.dnr.state.md.us/streams/status_trend/), but this program was directed at likely point source polluters and there was little emphasis on monitoring stream and riverine biodiversity.

There was, however, an early movement to protect rare species at the Federal level and in Maryland. Recognizing the inherent value of non-game species, the Maryland Nongame and Endangered Species Conservation Act of 1972 prohibits the direct removal or taking of listed animals without a permit, but does not require habitat protection or the development of recovery plans and recovery management. Similarly, the Federal Endangered Species Act of 1973 prohibits the taking of listed species. It also requires development and implementation of plans for species recovery.

In 1986, the Heritage Conservation Fund (HCF) was created by the Maryland legislature to facilitate acquisition of lands and conservation easements to protect high quality and Threatened and Endangered species habitat. This effort has been successful in protecting some freshwater habitats, but the majority of purchases and easements have been to protect terrestrial habitats and species.

Although there have been notable successes in species recovery at the national level, most rare aquatic species in Maryland continue to have inadequate protection, and there have been relatively few efforts to restore or enhance freshwater habitat. A notable exception is an ongoing effort to restore bog turtle habitat in Central Maryland. Historically, under funding and lack of strong regulatory and enforcement tools have limited protection and restoration efforts for freshwater biodiversity in Maryland.

Over time, natural resources management has increasingly moved away from single species approaches to an integrated approach that considers biological interactions as well as relationships between biota and their habitat. The original Chesapeake Bay Agreements in 1983 and 1987 contained little information that directly related to stream and riverine biodiversity; the emphasis was primarily on reducing nutrient levels in Chesapeake Bay. More recently, the 2000 version of the Bay Agreement included objectives that were much more holistic (http://www.chesapeakebay.net/agreement. htm). In 1996, DNR's intragency Ecosystem Council produced a document (Burke et al. 1996) that highlighted a set of outcomes that related to ecosystem-based management. These outcomes specified actions such as: an ecosystem management training initiative; development of an Integrated Natural Resources Management Plan; establishment of a DNR library and data center; and identification of a core network of protected lands representative of Maryland's native biodiversity.

The Unified Watershed Assessment, prepared in 1998 as part of the Clean Water Action Plan for Maryland (http://www.dnr.state.md.us/cwap/), categorized watersheds based on the degree of degradation and the presence of resources of concern. While this effort did incorporate some aspects of freshwater diversity, it also included terrestrial resources, drinking water supplies, and non-native fishery resources. In addition, it did not provide an overall ranking for each watershed. Still, it provided a means to focus on watersheds with significant aquatic resources that did not previously exist. Maryland took another step forward in 1998, when DNR sponsored a symposium on biodiversity. This event brought together resource agency staff, members of academia, and others from across the State to focus on the status and management of biodiversity in Maryland (DNR 2001).

In the past, planning and restoration activities for the Chesapeake Bay have received broad recognition as an ecosystem-based approach. However, the boundary lines of management emphasis have stopped at the head of tide. While many, if not most, management activities have necessarily looked upstream, the goal has been to improve the Chesapeake Bay and Coastal Bays. Consequently, benefits to freshwater biodiversity have been largely incidental. This pattern of management has been generally observed elsewhere (Blockstein 1992).

9.2.2 Present

In Maryland today, freshwater biodiversity is recognized as an important management goal in a number of ways. DNR's Mission Statement explicitly includes the need to provide for sustainability of living resources and aquatic habitats, and also calls for healthy watersheds and non-tidal habitat. The State is using several strategic land planning documents (DNR 1996; 2003a) for land planning purposes, forestry practices, and to guide fee simple land and easement acquisitions. At present, there are more than 500,000 acres of protected land in Maryland, and biodiversity values are a key strategic factor in land decisions. Other biodiversity-related activities include DNR's Integrated Natural Resource Assessment, a categorization of resource values for small (8-digit) watersheds in Maryland, and Greenprint, an effort to focus conservation efforts along hubs and corridors throughout the state. As these corridors often follow streams, this focus has the potential to be especially helpful in protecting freshwater biodiversity.

Because of its mission, DNR has a lead role in biodiversity conservation in Maryland. However, achieving biodiversity goals will take the help of many other agencies, groups, and citizens. It is important to note that at present, stream restoration and protection projects in Maryland do not often occur in watersheds with high biodiversity, and connectivity of high quality habitats is not a primary consideration during targeting. Nearly one half of the streams in Maryland are characterized as being in poor condition, and only about one in ten streams is rated in good condition (Roth et al. 1999; Volume 7 of this report). Thus, there is much room for improvement.

Management of freshwater biodiversity in Maryland is a rapidly evolving field. Prior to the mid-1990s, comprehensive statewide survey data for freshwater stream biota did not exist. Beginning in 1994 and every year since, a consistent method has been used to survey and inventory stream resources in the state. As a result, a quantitative database of ecological resources in Maryland streams is now being used as a tool for stream and riverine biodiversity conservation.

For Maryland counties within the coastal zone (16 of 23), the Maryland Coastal and Estuarine Land Conservation Plan (Burke *et. al.* 2004 draft) is being prepared. This plan should help focus protection of lands with significant ecological value, and will ultimately enable Maryland to compete for land preservation funding.

In accordance with the acceptance of State Wildlife Grants in 2004 funded from the federal Land and Water Conservation Fund, DNR is also currently preparing a Wildlife Diversity Conservation Plan for Maryland. Upon meeting this requirement, the State will receive funding for plan implementation, including monitoring, protection and restoration activities. When completed, this document should be a powerful tool for identifying the actions necessary to protect freshwater biodiversity in the State. Specifically, the plan will: list Great Conservation Need (GCN) species; contain information about the distribution and abundance of freshwater biota, identify and discuss key freshwater habitats and community types essential to conservation; outline stressors that adversely affect GCN species; specify conservation actions necessary to conserve GCN species; and identify monitoring, plan review, and coordination needs. This plan, and implementation of restoration and protection strategies that arise from it, represent an important opportunity to tie into county, state, and federal programs aimed at water quality improvement in estuarine areas, flood control and property protection, and other related activities. This volume on stream and riverine biodiversity was prepared, in part, as a supporting document to the Wildlife Diversity Conservation Plan. In addition to general information about Maryland fishes, stream herpetofauna, and benthic macroinvertebrates, this volume contains four appendices that also relate to the plan. GCN species of fishes and amphibians are described in Appendices A and B, respectively, and Appendix C pertains to benthic macroinvertebrates. Appendix D is a list of threats to individual watersheds in Maryland. This volume focuses on taxa for which comprehensive data exist. Protection of these taxa may serve to protect biodiversity of other taxa for which data are sparse. The reader should note that data on all levels of biodiversity (e.g. diatoms, bacteria, etc.) are sparse and many assemblages are not currently monitored in the state. The focus of this voume is on assemblages for which comprehensive data exist. It is assumed that protection of these assemblages will serve to protect biodiversity of all types.

MBSS WATERSHED UNITS

Because of practical and funding considerations, a series of Primary Sampling Units (PSUs) was established as a primary sampling strata for the MBSS. PSUs were based on 8 digit HUCs established by the United States Geological Survey and often represent true watersheds. However, the majority of PSUs include drainage divides and are thus not true watersheds at all. Thus, interpretation of ranking and other information presented in this report should consider PSUs to be more of a geographic area than true watersheds. For more information on the limations of HUCs, see Omernik and Bailey (1997).

9.3 FRESHWATER FISHES

This chapter provides information on various aspects of biodiversity for freshwater fishes. There are sections on fish populations, assemblage richness, and assemblage types, and a watershed-based ranking of fish biodiversity. Additional information on GCN fish species (identified as part of the Maryland Wildlife Diversity Conservation Plan; DNR in prep) is shown in Appendix A.

9.3.1 Populations

During the 2000-2004 MBSS, a total of 85 species were collected as part of the core MBSS sampling program (Table 9-1). Fish were sampled during the summer using intensive two-pass electrofishing of 75-m stream segments to provide an accurate characterization of species presence and numbers. Estimates of fish abundance are derived from species-specific electrofishing depletion results. The core MBSS sampling comprised approximately 2,500 probability-based (random) sites on all 1st- through 4th-order nontidal streams in Maryland. This provides the most accurate (but not a complete) characterization of fish distributions in the State. Additional targeted fish sampling has been conducted by the MBSS, but not all streams have been sampled nor all populations detected. Based on the Natural Heritage Program database and MBSS 1995-1997 results (Roth et al. 1999), nearly all of the stream fishes known to be extant in Maryland were collected during 2000-2004. One additional taxon,

Table 9-1. List of freshwater fish species collected by the MBSS during 1994- 2004, by 6 digit basin

Fish Family	Fish Species	Notes	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke
Lampreys: Petromyzontidae	American brook lamprey						1		X										
	Least brook lamprey						X	X	X	X	X	2	X		X	X	X	X	X
	Sea lamprey	d					X	X	X	S		X	X	X	X	X			
Gars: Lepisosteidae	Longnose gar							2											1
Freshwater Eels: Anguillidae	American eel			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Herrings: Clupeidae	Atlantic menhaden															S			
	Gizzard shad						X		X	1		S	S	S					
	Alewife						2	2								2			
	Blueback herring						2												
Pikes: Esocidae	Chain pickerel	Iy, g	X		X		X	X	X	X	X				1	X	X	X	X
	Redfin pickerel	Iy, g	X				1	X	X	X	X		X		X	X	X	X	X
Mudminnows: Umbridae	Eastern mudminnow						X	X	X	X	X		X		X	X	X	X	X
Minnows: Cyprinidae	Eastern blacknose dace		X	X	X	X	X	X	X	X	X	X	X	X	X	X			
	Bluntnose minnow		X	X	X	X	X		1		X	X	X	X					
	Central stoneroller		X	X	X	X	X	2	X		X	X		X					
	Comely shiner				X	X	X	S			1		1	S			1		
	Common carp	i	S	S	X	1	X	S	X	S	1		X	X	S	2			
	Common shiner		X	X	X	X	X	1	X		X	X	X	X	X				
	Creek chub		X	X	X	X	X	X	X		X	X	X	X	X				
	Cutlip minnow			X	X	X	X		X		X	X	X	X	X				
	Eastern silvery minnow					X	X	X	1		X	S	1	X	X		1		1
	Fallfish			X	X	X	X	X	X	X	X	1	X	X	1	X	X		
	Fathead minnow	i	X		X	X	X	X	X		X	1	2	S	2				
	Golden shiner		X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X

Table 9-1. (Continued))

Fish Family	Fish Species	Notes	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke
Minnows: Cyprinidae (cont'd)	Goldfish	i			X	2	X	S	S	1	X	2	X		2	2			
	Ironcolor shiner							X									1		
	Longnose dace		X	X	X	X	X	X	X		X	X	X	X	X				
	Pearl dace				X	X													
	River chub		X	X	X	X	X	S	X		X	X	X	X	X				
	Rosyface shiner			X	X	X	1	S	X		X	X	X	X	X				
	Rosyside dace		2	X	X	X	X	X	X	X	X	X	X	X	X	X	1		
	Satinfin shiner				S	X	X	X	X	1	X	X	X	X	X	X	X		X
	Silverjaw minnow				2	X	X				1	S							
	Spotfin shiner		S	X	X	X	X	S	X		X	S	S	X	2		S		
	Spottail shiner			X	X	X	X	X	X	1	X	X	S	X	X	X	X	S	
	Striped shiner		X		S														
	Swallowtail shiner				2	X	X	X	X	1	X	X	X	X	X	X	X		X
Suckers: Catostomidae	Creek chubsucker			X	X	X	X	X	X	X	X	S	X	1	X	X	X	X	X
	Golden redhorse			X	X	X	X		S										
	Northern hogsucker		X	X	X	X	X		X		X	X	X	X	X				
	Shorthead redhorse						1		X					S					
	White sucker		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
North Am. catfishes: Ictaluridae	Brown bullhead		X	X	X	X	X	X	X	1	X	X	X	X	X	X	1	X	X
	Channel catfish	ic			X	X	X		1		2			S					1
	Margined madtom	iy	X	X	X	X	X	X	X		X	X	X	X	X	X	1	X	X
	Stonecat		S																
	Tadpole madtom						2	X	X				2		S	X	X	X	X
	White catfish	iy					1	S	1			S				X			1
	Yellow bullhead		X	X	X	X	X	X	X		X	X	2	X	2	X	X	X	X

Table 9-1. (Continued

Fish Family	Fish Species	Notes	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke
Trouts: Salmonidae	Brook trout	g	X	X	X	X				2	X	X		X					
	Brown trout	g,i	X	X	X	X	1		X		X	1		X	1				
	Cutthroat trout	g,i		1	X						1								
	Rainbow trout	g,i	X	X	X	1	X		X	1	X	X	1	X	1				
Pirate Perches: Aphredoderidae	Pirate perch						X	X	X							X	X	X	X
Killifishes: Fundulidae	Banded killifish			2	S	X	X	X	X	X	X	2		X	X	X	X	S	
	Striped killifish								S										
	Mummichog						X	X	X	X	X	S	X	S	2	X	X		1
Livebearers: Poeciliidae	Mosquitofish					X	X	X	X	X	X	S			2	X	2	X	X
Sculpins: Cottidae	Checkered sculpin				X	X													
	Mottled sculpin		X																
	Potomac sculpin			X	X	X	X					2							
	Blue Ridge sculpin			X	X	X	X		X		X	X	X	X	X			X	
Striped Basses: Moronidae	Striped bass	g					2	X	1	1	X	S	S		X				
	White perch					S	1	S	X	1		S	X	X	X	X	1	X	1
Sunfishes: Centrarchidae	Banded sunfish								4	1			X				2	X	X
	Black crappie	ic		X	1		X	X	X	1	1				2	X	X	X	X
	Bluegill	ic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Bluespotted sunfish																		
	Flier							X											
	Green sunfish	ic	X	X	X	X	X	X	X	X	X	X	X	X	2	X	X		
	Largemouth bass	ic, g	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X
	Longear sunfish	ic			X	X	X					1							
	Mud sunfish															X	1	X	X
	Pumpkinseed	iy	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Redbreast sunfish	iy	S	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X

Table 9-1. (Continued)

Fish Family	Fish Species	Notes	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke
Sunfishes: Centrarchidae (cont'd)	Rock bass	ic	X	X	X	X	X		X		X	X		X					
	Smallmouth bass	ic,g	X	X	X	X	X	S	X		X	X	X	X	X		S		
	Warmouth							X	X	2					2	2			
	White crappie		S																
Perches: Percidae	Banded darter	i												S					
	Fantail darter		S	X	X	X	X					X							
	Glassy darter								X		2							X	1
	Greenside darter		X	X	X	X	X												
	Johnny darter		X																
	Logperch													X	1				
	Rainbow darter			X	X	X	X												
	Shield darter								X		S	X		X			1		S
	Stripeback darter								1										
	Swamp darter							X								1	1	X	X
	Tessellated darter		S	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Yellow perch	iy	X	X			X	X	X	X	X			X	S	X	1	X	X

Notes:
- 1 - Indicates that the species was caught at a random MBSS site during Round 1 (1994-1997)
- 2 - Indicates that the species was caught at a random MBSS site during Round 2 (2000-2004)
- X - Indicates that the species was caught at a random MBSS site during Round 1 and Round 2
- S - Indicates that the species was caught at a non-random supplemental site
- d - Diadromous
- g - Gamefish
- i - Introduced
- ic - Introduced to the Chesapeake drainage only
- iy - Introduced to the Youghiogheny drainage only

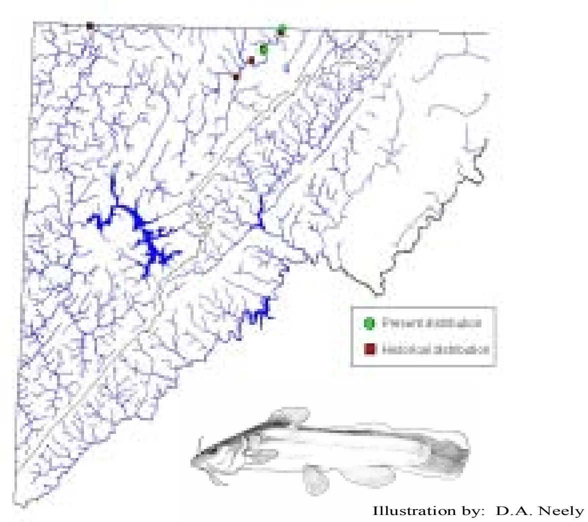
quillback (*Carpiodes cyprinus*; primarily a riverine species), was taken by an MBSS crew in the non-tidal Potomac River during this time (see Raesly and Kazyak 2004). A total of 84 fish species were collected during random sampling in both the 1995-1997 and 2000-2004 MBSS. Two alosid species, alewife (*Alosa psuedoharangus*) and American shad (*Alosa sapidissima*), were collected during 2000-2004 but not during 1995-1997 sampling. A third alosid, blueback herring (*Alosa aestivalis*), was collected during targeted sampling at an MBSS Sentinel site. These three species spawn in freshwater streams in spring but in most cases in Maryland, nursery areas are found in tidal waters and adults are no longer in freshwater streams and rivers during summer. Thus, the presence of juvenile alosids in non-tidal streams during summer is unusual.

In contrast, stripeback darter (*Percina notogramma*) was taken in low numbers at several locations during the 1995-1997 MBSS, but not during 2000-2004. This species has a highly restricted distribution and no random samples were located in the three streams where it is thought to still exist. Thus, the absence of this species at random MBSS sites during 2000-2004 is not unexpected and suggests the need for periodic, additional sampling targeted to track rare species.

Some species have never been collected at randomly selected core MBSS sites. These species include stonecat (*Noturus flavus*), white crappie (*Pomoxis annularis*), and Atlantic menhaden (*Brevoortia tyrannus*). Banded darter (*Etheostoma zonale*) was collected at only a single MBSS

STONECAT IN MARYLAND

The stonecat (*Noturus flavus*) is a small, nocturnal member of the catfish family, within a group commonly known as the madtoms. Within Maryland, it is listed as a State Endangered species because of its low abundance and highly restricted distribution. In an effort to define the specific distribution, population size, and habitat preferences of stonecat in Maryland, the University of Maryland Appalachian Laboratory conducted a field study in 1999 to supplement existing MBSS data (Kline and Morgan 2000). As a result of this study and subsequent MBSS sampling during 2000-2004, we now know that stonecat only occur in a small portion of the mainstem Casselman River. We also know that large boulders are important habitat for the species, and that there are likely fewer than 1000 individuals remaining in Maryland (the actual estimate was 660 fish). Because the entire population of stonecat appears to reside in a single stream reach, this population is highly vulnerable to a catastrophic water quality event such as a spill of chemicals, manure, or similar event. One potential way to minimize this risk would be to reintroduce stonecat to another stream where it formerly occurred. The Youghiogheny River in Maryland above Friendsville may provide such an opportunity. In 1929, highly acidic runoff from a gob pile fire in Crellin, West Virginia, rendered the mainstem Youghiogheny River essentially lifeless for more than 40 years. Today, the effects of the Crellin incident are gone, and there is now a trophy trout fishery in the river. Because of the similarity of habitat and the high degree of likelihood that stonecat once occurred in this location, a careful reintroduction program (either by translocating fish directly or through a captive breeding program) may be an effective means to ensure that stonecat remain a part of Maryland's freshwater biodiversity.



Distribution of stonecat in Maryland

site, in 1994. Of these, the presence of Atlantic menhaden in non-tidal freshwater is an extremely unusual occurrence. White crappie are found in non-tidal freshwater, but prefer lentic habitat and do not frequent wadable streams. In contrast, banded darter are found in wadable streams, but are introduced in Maryland (Susquehanna basin) and their abundance and distribution have apparently declined during the last several decades.

Stronghold watersheds were defined for each GCN species using a combination of quantitative abundance and distribution data, along with best professional judgment of experts in the ecology of each species. Although populations of GCN species in all watersheds are important, protection of these stronghold watersheds is considered to be essential to ensure the persistence of these species in Maryland.

Additional native stream and riverine species not collected during the core 2000-2004 MBSS, but recently collected during other efforts or with unknown status in Maryland include redside dace (*Clinostomus elongatus*); Maryland darter (*Etheostoma sellare*); cheat minnow (*Pararhinichthys bowersi*); longnose sucker (*Catostomus catostomus*); bridle shiner (*Notropis bifrenatus*), and stonecat (*Noturus flavus*). Qualitative surveys were conducted for bridle shiner (*Notropis bifrenatus*) and blackbanded sunfish (*Enneacanthus chaetodon*) at historical localities and other likely habitat, but no individuals of these species were taken (Raesly and Kazyak 2004). A further description of these and other fishes, deemed species of Greatest Conservation Need, is provided in Appendix A. This appendix provides summary information about life history, habitat, distribution and abundance, watersheds, stressors, conservation actions, and monitoring needs.

Based on estimates calculated from randomly selected MBSS sites during 2000-2004, there are approximately 91 million fishes in 1^{st}-4^{th} order streams in Maryland (Table 9-2). The five most abundant species included eastern blacknose dace (*Rhinichthys atratulus*), eastern mudminnow (*Umbra pygmaea*), Blue Ridge sculpin (*Cottus caeruleomentum*), bluntnose minnow (*Pimephales notatus*), and creek chub (*Semotilus atromaculatus*). Resident stream species with population estimates less than 5000 individuals included: stonecat (*Noturus flavus*), ironcolor shiner (*Notropis chalybaeus*), striped shiner (*Luxillus chrysocephalus*), and logperch (*Percina caprodes*).

Using a rarity-weighted index by watershed, three species, bluegill, largemouth bass, and pumpkinseed, were the most widely distributed freshwater fishes in the state (Table 9-2). The least widely distributed fishes in 1^{st}-4^{th} order streams and rivers were inland silverside (IMenidia beryllina), American shad (*Alosa sapidissima*), checkered sculpin (*Cottus spin*), striped shiner (*Luxillus cornutus*), Johnny darter (*Etheostoma Nigrum*), cutthroat trout (*Oncorhynchus clarki*), logperch (*Perina caprodes*), ironcolor shiner (*Notropis chalybaeus*), pearl dace (*Margariscus margarita*), and flier (*Centrarchus macropterus*). Of these, inland silverside is a stray from tidal habitat, American shad juveniles primarily reside in fresh or low salinity tidal habitat, and cutthroat trout are non-native and stocked in only a small portion of the state. Two of the ten most restricted species (checkered sculpin and pearl dace) occur primarily in the Great Valley area of the state, two more species (Johnny darter and striped shiner) are restricted to the Ohio drainage, two (flier and ironcolor shiner) are found only in certain areas of the Coastal Plain, and one (logperch) does not extend beyond a few streams in the upper Chesapeake Bay.

The statewide status of freshwater fish populations in Maryland provides valuable information for biodiversity management. However, there may be isolated populations of even common species that are at risk of local extirpation because of low abundance. As with the 1995-1997 MBSS, population estimates for each native species in each 6-digit drainage basin were examined, and species with less than 500 individuals and a reasonable degree of isolation from other populations based on salinity and other migration barriers were listed as vulnerable to local extirpation (Table 9-3).

NON-NATIVE SPECIES KNOWN OR THOUGHT TO BE EXTANT IN MARYLAND BUT NOT COLLECTED AT RANDOMLY SELECTED SITES DURING THE 2000-2004 MBSS INCLUDE:

Grass carp (*Ctenopharyngodon idella*)
White crappie (*Pomoxis nigromaculatus*)
Redear sunfish (*Lepomis microlophus*)
Walleye (*Sander vitreus*)
Northern pike (*Esox lucius*)
Muskellunge (*Esox masquinongy*)
Northern snakehead (*Channa argus*)
Lake trout (*Salvelinus namaycush*)
Banded darter (*Etheostoma zonale*)

NOTE: *Non-native species are defined by the MBSS as those species not originating from the major drainage in Maryland (Atlantic slope or Ohio River) in which they are collected.*

Of the 58 species-basin combinations listed as being locally vulnerable in either the 1995-1997 or 2000-2004 periods, 24 declined or were absent in 2000-2004. An additional 15 had population estimates with standard errors that encompassed the previous estimate, and 10 species were found in a basin in low numbers in 2000-2004 but not collected in 1995-1997. Additionally, estimates for 9 species increased above 500 individuals, including the standard error. Four of the nine instances where population estimates increased were in western Maryland, where forest is the dominant land cover. In

Table 9-2. Statewide population estimates and relative rarity for fish species collected by the MBSS during 2000-2004. Many of these species occur primarily in estuaries, tidal streams, reservoirs, ponds, or larger rivers; these population estimates are for 1st-4th order freshwater streams.

Family	Common Name	Scientific Name	Population Estimate	Standard Error	Relative Standard Error	Rarity Weighted Index
Petromyzontidae						
	Least Brook Lamprey	*Lampetra aepyptera*	1,218,006	444,019	0.36	50.0
	American Brook Lamprey	*Lampetra appendix*	16,085	8,853	0.55	8.3
	Sea Lamprey	*Petromyzon marinus*	312,474	144,423	0.46	31.0
Lepisosteidae						
	Longnose Gar	*Lepisosteus osseus*	- -	- -	- -	2.4
Anguillidae						
	American Eel	*Anguilla rostrata*	1,885,854	237,320	0.13	85.7
Clupeidae						
	Blueback Herring	*Alosa aestivalis*	- -	- -	- -	1.2
	Alewife	*Alosa pseudoharengus*	939	939	1.00	2.4
	American Shad	*Alosa sapidissima*	34,106	33,966	1.00	1.2
	Gizzard Shad	*Dorosoma cepedianum*	17,342	7,319	0.42	11.9
Cyprinidae						
	Central Stoneroller	*Campostoma anomalum*	1,275,817	285,890	0.22	39.3
	Goldfish	*Carassius auratus*	2,984	1,024	0.34	20.2
	Rosyside Dace	*Clinostomus funduloides*	2,768,643	252,152	0.09	66.7
	Satinfin Shiner	*Cyprinella analostana*	366,824	97,017	0.26	54.8
	Spotfin Shiner	*Cyprinella spiloptera*	444,668	198,406	0.45	50.0
	Common Carp	*Cyprinus carpio*	2,777	1,073	0.39	36.9
	Cutlip Minnow	*Exoglossum maxillingua*	513,129	67,232	0.13	45.2
	Eastern Silvery Minnow	*Hybognathus regius*	65,493	55,693	0.85	32.1
	Striped Shiner	*Luxilus chrysocephalus*	190	190	1.00	3.6
	Common Shiner	*Luxilus cornutus*	982,909	177,389	0.18	54.8
	Pearl Dace	*Margariscus margarita*	134,983	110,418	0.82	6.0
	River Chub	*Nocomis micropogon*	1,208,206	780,994	0.65	47.6
	Golden Shiner	*Notemigonus crysoleucas*	748,061	151,793	0.20	79.8
	Comely Shiner	*Notropis amoenus*	13,053	7,129	0.55	17.9
	Silverjaw Minnow	*Notropis buccatus*	515,093	313,406	0.61	14.3
	Ironcolor Shiner	*Notropis chalybaeus*	4,800	4,800	1.00	4.8
	Spottail Shiner	*Notropis hudsonius*	2,454,881	1,771,155	0.72	66.7
	Swallowtail Shiner	*Notropis procne*	897,541	199,182	0.22	53.6
	Rosyface Shiner	*Notropis rubellus*	183,922	82,316	0.45	34.5
	Bluntnose Minnow	*Pimephales notatus*	6,522,897	2,652,632	0.41	41.7
	Fathead Minnow	*Pimephales promelas*	87,984	32,852	0.37	36.9
	Eastern Blacknose Dace	*Rhinichthys atratulus*	14,343,129	798,493	0.06	81.0
	Longnose Dace	*Rhinichthys cataractae*	2,524,940	313,648	0.12	56.0
	Creek Chub	*Semotilus atromaculatus*	3,524,739	289,317	0.08	69.0
	Fallfish	*Semotilus corporalis*	1,178,279	294,751	0.25	65.5

Table 9-2. (Continued)						
Family	**Common Name**	**Scientific Name**	**Population Estimate**	**Standard Error**	**Relative Standard Error**	**Rarity Weighted Index**
Catostomidae						
	White Sucker	*Catostomus commersonii*	2,967,035	281,078	0.09	79.8
	Creek Chubsucker	*Erimyzon oblongus*	687,579	115,343	0.17	70.2
	Northern Hog Sucker	*Hypentelium nigricans*	265,115	62,861	0.24	51.2
	Golden Redhorse	*Moxostoma erythrurum*	12,539	7,714	0.62	19.0
	Shorthead Redhorse	*Moxostoma macrolepidotum*	118	118	1.00	7.1
Ictaluridae						
	White Catfish	*Ameiurus catus*	301	301	1.00	11.9
	Yellow Bullhead	*Ameiurus natalis*	258,624	91,832	0.36	67.9
	Brown Bullhead	*Ameiurus nebulosus*	460,987	488,224	1.06	77.4
	Channel Catfish	*Ictalurus punctatus*	3,724	2,270	0.61	20.2
	Stonecat	*Noturus flavus*	660	- -	- -	1.2
	Tadpole Madtom	*Noturus gyrinus*	202,218	133,798	0.66	33.3
	Margined Madtom	*Noturus insignis*	733,458	408,676	0.56	69.0
Esocidae						
	Redfin Pickerel	*Esox americanus*	570,126	129,532	0.23	47.6
	Chain Pickerel	*Esox niger*	68,680	11,043	0.16	40.5
Umbridae						
	Eastern Mudminnow	*Umbra pygmaea*	12,498,604	2,140,057	0.17	54.8
Salmonidae						
	Cutthroat Trout	*Oncorhynchus clarki*	117	117	1.00	3.6
	Rainbow Trout	*Oncorhynchus mykiss*	14,514	4,793	0.33	38.1
	Brown Trout	*Salmo trutta*	247,316	93,617	0.38	38.1
	Brook Trout	*Salvelinus fontinalis*	407,262	69,942	0.17	21.4
Aphredoderidae						
	Pirate Perch	*Aphredoderus sayanus*	1,549,770	905,638	0.58	31.0
Atherinidae						
	Inland Silverside	*Menidia beryllina*	1,108	1,108	1.00	1.2
Fundulidae						
	Banded Killifish	*Fundulus diaphanus*	109,101	47,412	0.43	34.5
	Mummichog	*Fundulus heteroclitus*	197,474	96,245	0.49	29.8
	Striped Killifish	*Fundulus majalis*	- -	- -	- -	1.2
Poeciliidae						
	Eastern Mosquitofish	*Gambusia holbrooki*	376,892	164,792	0.44	52.4
Cottidae						
	Blue Ridge Sculpin	*Cottus caeruleomentum*	7,341,496	830,343	0.11	41.7
	Mottled Sculpin	*Cottus bairdii*	687,961	186,349	0.27	3.6
	Checkered Sculpin	*Cottus sp.*	60,251	41,524	0.69	2.4
	Potomac Sculpin	*Cottus girardi*	1,504,276	394,846	0.26	26.2
Percichthyidae						
	White Perch	*Morone americana*	1,791	862	0.48	31.0
	Striped Bass	*Morone saxatilis*	1,857	952	0.51	16.7

Table 9-2. (Continued)						
Family	**Common Name**	**Scientific Name**	**Population Estimate**	**Standard Error**	**Relative Standard Error**	**Rarity Weighted Index**
Centrarchidae						
	Mud Sunfish	*Acantharchus pomotis*	9,128	3,377	0.37	10.7
	Rock Bass	*Ambloplites rupestris*	190,134	43,192	0.23	38.1
	Flier	*Centrarchus macropterus*	6,588	5,197	0.79	6.0
	Bluespotted Sunfish	*Enneacanthus gloriosus*	494,446	108,404	0.22	34.5
	Banded Sunfish	*Enneacanthus obesus*	83,702	43,633	0.52	14.3
	Redbreast Sunfish	*Lepomis auritus*	771,869	104,004	0.13	78.6
	Green Sunfish	*Lepomis cyanellus*	1,000,153	255,245	0.26	69.0
	Pumpkinseed	*Lepomis gibbosus*	893,175	164,911	0.18	96.4
	Warmouth	*Lepomis gulosus*	34,429	18,597	0.54	17.9
	Bluegill	*Lepomis macrochirus*	1,630,342	240,248	0.15	96.4
	Longear Sunfish	*Lepomis megalotis*	16,114	6,551	0.41	14.3
	Smallmouth Bass	*Micropterus dolomieu*	275,775	49,812	0.18	54.8
	Largemouth Bass	*Micropterus salmoides*	236,345	31,312	0.13	96.4
	Black Crappie	*Pomoxis nigromaculatus*	15,048	8,031	0.53	35.7
	White Crappie	*Pomoxis annularis*				1.2
Percidae						
	Greenside Darter	*Etheostoma blennioides*	2,658,390	4,767,241	1.79	22.6
	Rainbow Darter	*Etheostoma caeruleum*	249,336	82,811	0.33	14.3
	Fantail Darter	*Etheostoma flabellare*	2,137,230	424,363	0.20	29.8
	Swamp Darter	*Etheostoma fusiforme*	9,734	3,742	0.38	14.3
	Johnny Darter	*Etheostoma nigrum*	31,958	16,142	0.51	3.6
	Tessellated Darter	*Etheostoma olmstedi*	4,907,866	612,645	0.12	86.9
	Glassy Darter	*Etheostoma vitreum*	27,602	23,244	0.84	7.1
	Banded Darter	*Etheostoma zonale*	- -	- -	- -	2.4
	Yellow Perch	*Perca flavescens*	13,321	5,210	0.39	42.9
	Logperch	*Percina caprodes*	1,342	1,342	1.00	4.8
	Stripeback Darter	*Percina notogramma*	- -	- -	- -	1.2
	Shield Darter	*Percina peltata*	60,567	23,125	0.38	16.7
Sciaenidae						
	Spot	*Leiostomus xanthurus*				1.2

contrast, six of the fourteen instances where species were not collected in 2000-2004 occurred in the Potomac Washington Metro and West Chesapeake basins, both of which are undergoing a high degree of urbanization.

Although little is known about minimum population sizes necessary for maintaining long-term viability of stream and riverine species, there is likely a density threshold for each species below which any additional human-induced or natural stress may cause local extirpation. Frissell (1997) stated that many stream and riverine species have persisted over time by being able to recolonize following periodic events that caused local extinction. In Maryland, the large number of migration barriers in streams and rivers reduces the likelihood of recolonization, especially in the most developed areas. Further, the loss of refuge areas from various stressors increases the likelihood of extirpation.

In contrast to basins with vulnerable populations are watersheds that serve as strongholds, especially for rare species. For GCN species, a description of stronghold watersheds for each species is provided in Appendix A. The watersheds which had the highest rankings as strongholds for GCN species included the Youghiogheny River and Casselman River in western Maryland, Upper Monocacy River, and Antietam Creek in central Maryland, Broad Creek in the upper Chesapeake Bay region, St. Mary's River, Breton Bay/St. Clements Bay, and Zekiah Swamp in southern Maryland, and Upper Pocomoke, Tuckahoe Creek, Dividing Creek/ Nassawango Creek, and Marshyhope Creek on the eastern

Table 9-3. List of isolated or partially isolated fish species with population estimates in a drainage basin less than 500 individuals during either the 1995-1997 or 2000-2004 MBSS, with Standard Error estimates (SE)

		1995-1997		2000-2004	
Basin	**Species**	**Estimate**	**S.E.**	**Estimate**	**S.E.**
Youghiogheny	Green sunfish	110	114	13,795	11,138
	Smallmouth bass	264	243	14,645	13,414
	Striped shiner	330	339	190	190
	Bluegill	440	451	4641	2635
	Rosyside Dace	Not collected	N/A	306	306
North Br. Potomac	Creek chubsucker	144	133	2,879	2,879
	Rainbow darter	144	144	6,678	6,270
	Pumpkinseed	212	133	1,489	1,046
	Tessellated darter	Not collected	Not collected	72	72
Upper Potomac	River chub	61	61	Not collected	N/A
	Northern hogsucker	490	368	19,779	10,823
Middle Potomac	Swallowtail shiner	272	242	285	285
	Creek chubsucker	471	284	21,835	20,071
	Pearl dace	549	605	270	270
Potomac Washington Metro	Bluespotted sunfish	65	53	Not collected	N/A
	Redfin pickerel	194	194	Not collected	N/A
	American brook lamprey	362	270	Not collected	N/A
	Pirate perch	Not collected	N/A	151	151
	River chub	888	624	270	270
	Tadpole madtom	Not collected	N/A	151	151
	Shorthead redhorse	Not collected	N/A	118	118
Lower Potomac	Swamp darter	138	94	1,140	975
	Common shiner	268	281	Not collected	N/A
Patuxent	Chain pickerel	121	141	977	750
	Bluntnose minnow	134	112	Not collected	N/A
	Shorthead redhorse	362	359	118	118
West Chesapeake	Swallowtail shiner	19	19	Not collected	N/A
	Redbreast sunfish	19	21	Not collected	N/A
	Satinfin shiner	154	123	Not collected	N/A
	Rosyside dace	12,053	12,014	122	122
	Brook trout	Not collected	N/A	297	297
	Warmouth	Not collected	N/A	122	122
Patapsco River	Bluespotted sunfish	258	258	2,001	1,874
	Chain pickerel	322	275	1,350	896
	Redfin pickerel	345	345	2,445	971
	Creek chubsucker	460	507	1,120	605
	Spotfin shiner	1,075	1,084	123	123
	Glassy darter	Not collected	N/A	123	123
Gunpowder River	Fallfish	123	113	Not collected	N/A
Bush River	Sea lamprey	287	264	3,357	2,169
	Eastern mudminnow	469	457	19,958	15,680
	Tadpole madtom	Not collected	N/A	61	61
Susquehanna River	Golden shiner	172	100	673	673
	Spotfin shiner	2,467	2,733	348	348
Elk River	Least brook lamprey	61	53	14,305	6,864
	Logperch	182	182	Not collected	N/A
	Warmouth	Not collected	N/A	108	108
Chester River	Sea lamprey	71	40	508	508
	Rosyside dace	115	102	7,960	7,628
	Swamp darter	472	340	Not collected	N/A

Table 9-3. (Continued)					
		1995-1997		2000-2004	
Basin	**Species**	**Estimate**	**S.E.**	**Estimate**	**S.E.**
Choptank River	Swamp darter	115	92	369	369
	Ironcolor shiner	138	84	Not collected	N/A
	Mud sunfish	138	85	Not collected	N/A
	Banded sunfish	Not collected	N/A	322	322
Nanticoke Wicomico	Mud sunfish	752	717	140	140
	Glassy darter	3,296	2,862	249	249
Pocomoke River	Glassy darter	49	33	Not collected	N/A
	Chain pickerel	110	86	1,373	1,163
	Least brook lamprey	1,908	913	310	225

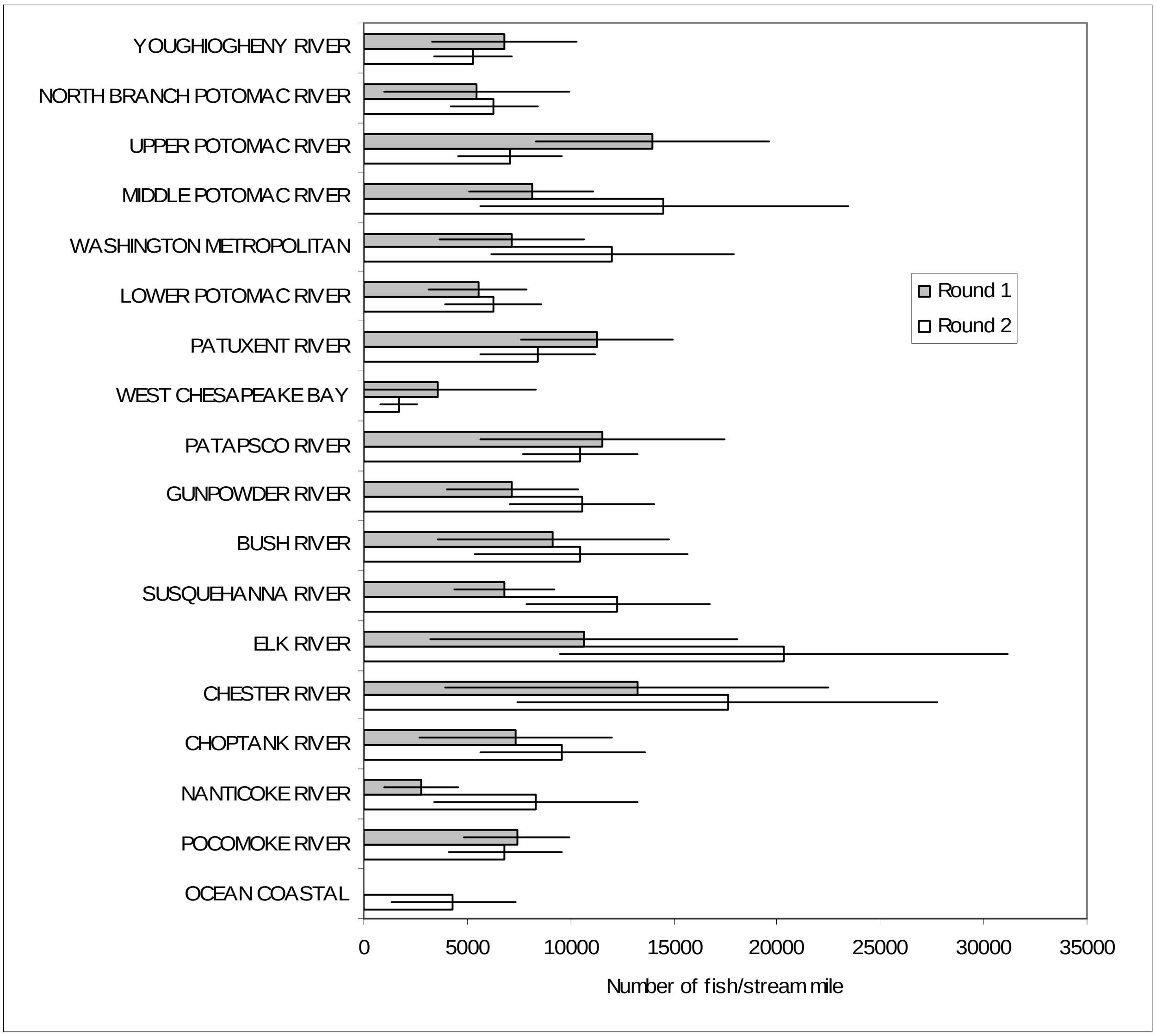


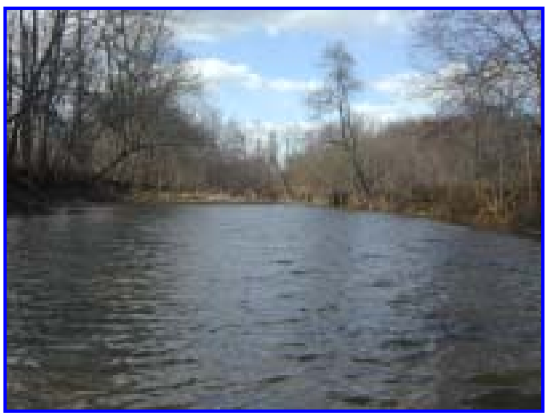
Figure 9-1. Quantitative estimates of fish density, by basin, based on the 1995-1997 and 2000-2004 MBSS

shore. In contrast, 21 of the 84 watersheds were not strongholds for any of the GCN fish species. Thus, three quarters of the watersheds in Maryland serve as a stronghold for at least one GCN fish species, and may warrant management emphasis on that basis.

9.3.2 Density and Biomass

Overall, the basins with the highest fish densities per stream mile during 2000-2004 sampling were the Elk, Chester, and Middle Potomac Rivers, all with more than 14,000 fishes per stream mile (Figure 9-1). In contrast, fish density in the West Chesapeake basin was estimated at 1,679 per stream mile, well below densities observed in any other basin. In 10 of 17 basins for which data were available from both sampling rounds, there was an overlap in the density estimates, and the statewide mean for both rounds was nearly identical (10,324/mile for 1995-1997; 9,619/mile for 2000-2004).

RECORD FISH ABUNDANCE: Double Pipe Creek in Carroll County contained the greatest number of fish ever collected during the MBSS. A total of 11,354 fish, representing 26 species were collected at this site in 2002, nearly 8000 of which were bluntnose minnows. In spite of the abundance and number of species, the Fish IBI rating for the site was Fair because of the dominance of pollution tolerant species.



Statewide, 19 % of all stream miles were fishless during 2000-2004; this estimate declined to 16.4% of stream miles when streams with watersheds less than 300 acres were excluded from the analysis (Figure 9-2). The basins with the highest proportion of streams without fishes included the Nanticoke, Upper Potomac, and West Chesapeake. Approximately 30% of the stream miles in each of these basins were devoid of fishes. In contrast, fishes were found in 95% of the streams in the Susquehanna basin.

Across Maryland, the mean biomass per 75m segment was 2.43 kg (Figure 9-3). Basins with the highest mean biomass per site included the Elk River at 5.92 kg/75m and the Susquehanna River at 5.81 kg/75m. In contrast, mean biomass per site in the West Chesapeake basin was 0.28 kg/75m, more than 20-fold less than in the high biomass basins.

9.3.3 Fish Assemblage Richness

One way to evaluate freshwater biodiversity is to count the number of species within a site or within a watershed. A drawback with this method, however, is that some habitat types have naturally fewer species than others because of environmental conditions such as cold water or low pH. To more thoroughly account for these natural variations, Stranko et al. (in press) used MBSS data to develop an expected suite of fish species for each site based on zoogeographic dis-riutions of fishes and the physical and chemical charac-teristics of streams where they were collected. From this, an observed vs. expected (O/E) ratio was calculated as a measure of assemblage intact-ness. To establish a watershed ranking of assemblage intact-ness using O/E, the number of sites with O/E > 0.75 (on a 0 to 1.0 scale) were summed and then adjusted by the total stream miles in each watershed to avoid inherent bias against small watersheds. Based on this metric, the Eastern Bay/Kent Narrows/Lower Chester River/

RECORD FISH DENSITY: Surprisingly, the greatest density of fish collected during the 1994 – 2004 MBSS was found in an unnamed tributary to Windmill Branch in Talbot County. In spite of poor instream habitat, low dissolved oxygen, and an average width of only 0.5, nearly 18 fish per square meter were found. Of the four species and 703 individuals collected, 694 were Eastern mud minnow. This species does not compete well with other species, but can live in streams with extremely low pH and very little dissolved oxygen. Because of its penchant for borrowing in mud, it is normally more abundant in streams with poor habitat. This stream is a clear example of a positive response by a pollution and habitat- tolerant species to degradation, and a caution that abundance is not always a sign of health.

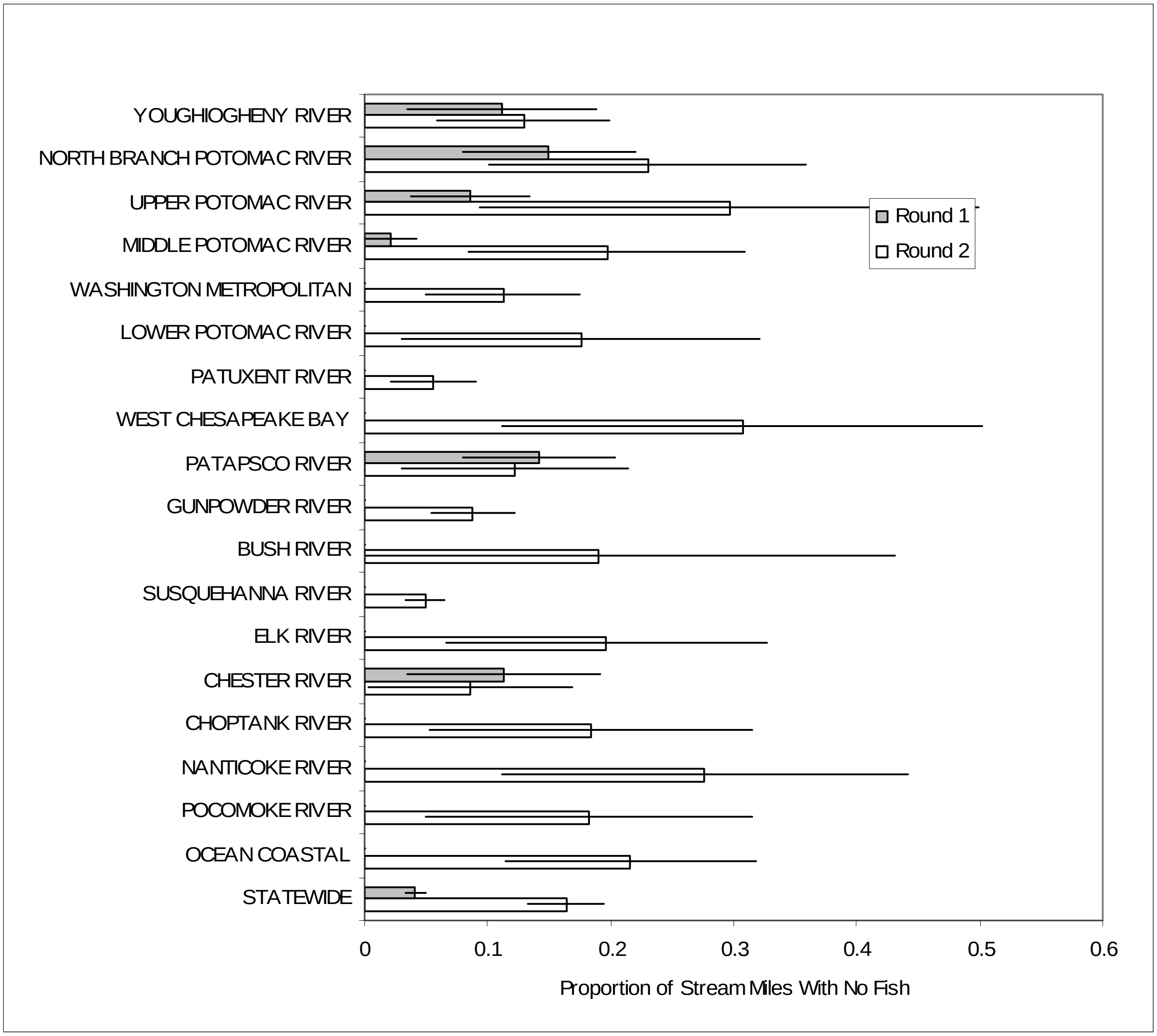


Figure 9-2. Bar graph of stream miles with no fishes, by basin and statewide, during the 2000-2004 MBSS

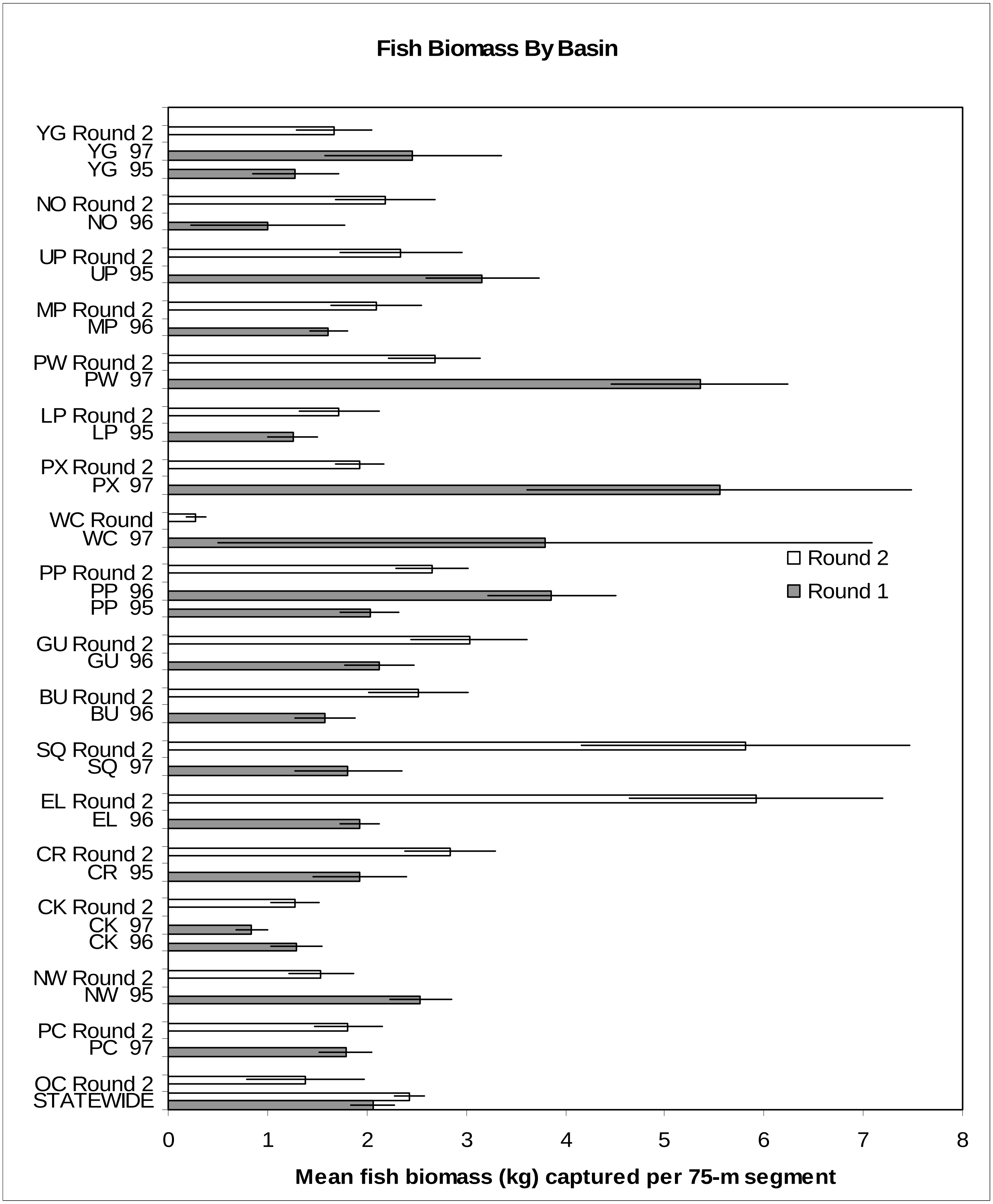


Figure 9-3. Mean fish biomass per 75m segment, by basin and statewide, during the 2000-2004 MBSS

Langford Creek/Kent Island Bay, Upper Pocomoke River, and Broad Creek watersheds had the highest degree of fish assemblage intactness in the state (Figure 9-4). In contrast, few or no high O/E sites occurred in the Breton Bay/St. Clements Bay, Bodkin Creek/ Baltimore Harbor, Coastal Bays drainages, and Conococheague Creek watersheds.

9.3.4 Distinct Fish Assemblage Types

Based on the work of Kilian (2004), who applied multivariate statistics to MBSS data to identify stream fish assemblage types, there are 16 unique stream fish assemblages in Maryland. These assemblages are distinct in species composition, geographic distribution, and associated habitat characteristics (Table 9-4; Figure 9-5).

Historical processes and current environmental gradients influence assemblage structure at the statewide scale. The regional pool of species occurring in Maryland is the result of geological events involving four major river systems, Susquehanna, Delaware, Potomac, and Monongahela Rivers (Lee 1976). Present distributions of stream fishes in Maryland are determined, in part, by historical dispersal over geologic time. This has involved the exchange and movement of species between drainages in response to shifts in drainage patterns during the Pleistocene epoch, as well as isolated stream capture episodes. Although these drainages share many species in common, there are species with restricted distributions that make these drainages distinct.

A distinct west-to-east pattern in assemblage structure is apparent in all stream orders in Maryland. This pattern is due in part to the historical origins and drainage configurations of the Monongahela and Potomac Rivers in the west and the Susquehanna and Delaware Rivers in the east. Nested within this historical context, environmental gradients strongly influence assemblage structure statewide. These physical and chemical gradients are related to physiography. Strong gradients in water chemistry (e.g., pH, dissolved oxygen, and dissolved organic carbon) influence assemblage structure across the State. Physical gradients in substrate embeddedness, water temperature, and physical habitat quality also influence assemblage structure at this scale.

Gradients in environmental conditions are also important in structuring stream fish assemblages in Maryland. Assemblage structure in the non-Coastal Plain region is controlled primarily by differences in elevation. Sculpin-dominated assemblages in all three stream orders are consistently found at higher elevations than other non-Coastal Plain assemblage types. Low elevation non-Coastal Plain assemblages are rich in species and typically dominated by cyprinids. Other variables (e.g., embeddedness, instream habitat quality, riffle/run quality) known to influence assemblage structure within this region suggest that assemblage composition is influenced by stream gradient. Stream gradient is known to influence the distribution of fish species (Hocutt & Stauffer 1975), and is likely an important factor influencing assemblage structure in the non-Coastal Plain region of Maryland. Assemblage structure in the Coastal Plain region of Maryland is influenced primarily by gradients in stream size and water chemistry. Smaller stream assemblages of this region are often dominated by tolerant, pioneering species such as the Eastern mudminnow. Assemblages of blackwater streams are comprised of species (e.g., pirate perch, tadpole madtom) tolerant of acidic conditions and low dissolved oxygen concentrations typical of swampy lowlands.

For first-order streams, three non-Coastal Plain and two Coastal Plain assemblages were identified. Examples of the driving influences separating these assemblage types included: stream elevation, riffle quality and substrate embeddedness, physiographic region, and stream size. The numerical dominance of eastern blacknose dace, Blue Ridge sculpin, or eastern mudminnow was an important biological difference separating the assemblages.

In second-order streams, seven unique assemblages were identified, including blackwater, Highland (limestone), and coldwater types. Again, the primary factors defining these assemblages included physiographic region and stream elevation, but other characteristics associated with these assemblages were acid neutralizing capacity, dissolved organic carbon, and pH. For third-order streams, four distinct assemblages were apparent, and physiographic region, stream size and elevation, and habitat quality were among the major environmental gradients.

The classification of stream fish assemblages presented above represents a preliminary description of major assemblage patterns in Maryland, along with an evaluation of the major environmental gradients. Although rare species were included in the classification analysis, common and abundant species were most important in determining assemblage classes. The reader should note that establishment of criteria for cluster analysis is a somewhat arbitrary process, and that further classification analysis that emphasizes rare species, finer spatial scales, fourth- and fifth-order streams, and anthropogenic influences on assemblage structure is likely improve the state of knowledge about stream fish assemblages in Maryland.

9.3.5 Evolutionarily Significant Units

Another aspect of biodiversity that has important management implications is genetics. Over geologic time, geographic isolation of populations can lead to speciation, thus it is important to consider populations as well as species when prioritizing protection and restoration efforts. In Maryland, there are a number of watersheds

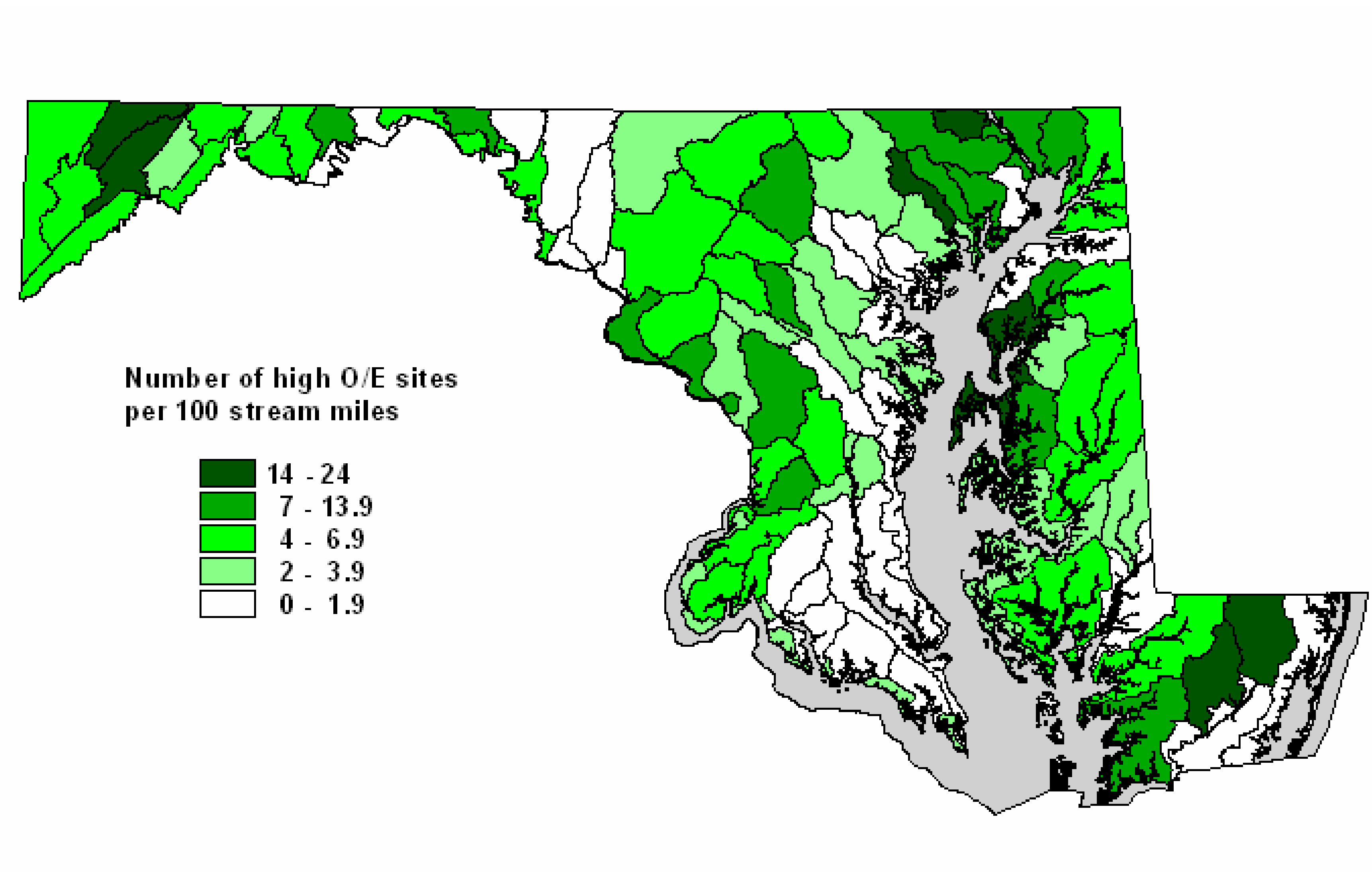


Figure 9-4. Map of Maryland watersheds, scored by the number of high (> 0.75 on a 0 to 1.0 scale) Observed vs. Expected scores (after Stranko et al. in press) for fishes based on 1995-2004 MBSS data. Note: scores were adjusted by stream miles in each watershed to avoid a size bias.

Table 9-4. Characteristics and member species of sixteen distinct stream fish assemblage types in Maryland based on classification and ordination analyses of 1995-1997 MBSS data (*from* Kilian 2004)

Stream Order	Region	Assemblage	Member Species (present at >=50% of sites)	Characteristics
First	Non-Coastal Plain	Pioneer	Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*)	- Numeric dominance of Eastern mudminnow - Small headwater streams - Low species richness
		Warmwater	Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) Rosyside dace (*Clinostomus funduloides*) White sucker (*Catostomus commersonii*)	- Low elevation streams - High species richness
		Coolwater	Blue Ridge sculpin (*Cottus caeruleomentum*)* Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) Rosyside dace (*Clinostomus funduloides*) White sucker (*Catostomus commersonii*) * Replaced with Mottled sculpin (*Cottus bairdii*) in Youghiogheny River basin.	- High elevation streams - High riffle/run quality - Low substrate embeddedness
	Coastal Plain	Mudminnow	Eastern mudminnow (*Umbra pygmaea*)	- Numeric dominance of eastern mudminnow - Small headwater Coastal Plain streams - Low dissolved oxygen concentrations - Low pH - Low species richness
		Coastal	Eastern mudminnow (*Umbra pygmaea*) American eel (*Anguilla rostrata*) Bluegill (*Lepomis macrochirus*) Creek chubsucker (*Erimyzon oblongus*) Redfin pickerel (*Esox americanus*) Pumpkinseed (*Lepomis gibbosus*) Pirate perch (*Aphredoderus sayanus*) Tessellated darter (*Etheostoma olmstedi*)	- Large first-order Coastal Plain streams - High species richness

Table 9-4. (Continued)

Stream Order	Region	Assemblage	Member Species (present at >=50% of sites)	Characteristics
Second	Non-Coastal Plain	Tolerant	Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) White sucker (*Catostomus commersonii*)	- Numeric dominance of eastern blacknose dace - Small second-order streams - Low species richness - Common assemblage of urban streams
		Piedmont	Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) Rosyside dace (*Clinostomus funduloides*) Longnose dace (*Rhinichthys cataractae*) Common shiner (*Luxilus cornutus*) Tessellated darter (*Etheostoma olmstedi*) Cutlip minnow (*Exoglossum maxillingua*) Northern hogsucker (*Hypentelium nigricans*) American eel (*Anguilla rostrata*) White sucker (*Catostomus commersonii*)	- High species richness - Low elevation Piedmont streams
		Highland	Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) Fantail darter (*Etheostoma flabellare*) Longnose dace (*Rhinichthys cataractae*) White sucker (*Catostomus commersonii*)	- High acid neutralizing capacity (ANC)
		Coldwater	Brook trout (*Salvelinus fontinalis*) Blue Ridge sculpin (*Cottus caeruleomentum*)* Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) Longnose dace (*Rhinichthys cataractae*) White sucker (*Catostomus commersonii*) * Replaced with Mottled sculpin (*Cottus bairdii*) in Youghiogheny River basin.	- High elevation second-order streams - Forested watersheds

Table 9-4. (Continued)

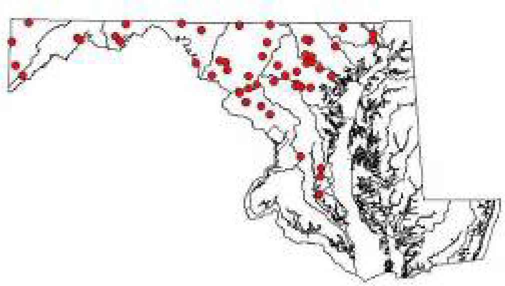
Stream Order	**Region**	**Assemblage**	**Member Species (present at >=50% of sites)**	**Characteristics**
Second	Coastal Plain	Blackwater	Eastern mudminnow (*Umbra pygmaea*) American eel (*Anguilla rostrata*) Redfin pickerel (*Esox americanus*) Creek chubsucker (*Erimyzon oblongus*) Pumpkinseed (*Lepomis gibbosus*) Tessellated darter (*Etheostoma olmstedi*) Bluegill (*Lepomis macrochirus*) Golden shiner (*Notemigonus crysoleucas*) Pirate perch (*Aphredoderus sayanus*) Tadpole madtom (*Noturus gyrinus*)	- High dissolved organic carbon (DOC) - Low dissolved oxygen concentrations - Low pH
		Coastal Plain	Eastern mudminnow (*Umbra pygmaea*) American eel (*Anguilla rostrata*) Creek chubsucker (*Erimyzon oblongus*) Pumpkinseed (*Lepomis gibbosus*) Tessellated darter (*Etheostoma olmstedi*) Bluegill (*Lepomis macrochirus*) Redbreast sunfish (*Lepomis auritus*) White sucker (*Catostomus commersonii*)	- High physical habitat quality
Third	Non-Coastal Plain	Coolwater	Blue Ridge sculpin (*Cottus caeruleomentum*)* Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) Longnose dace (*Rhinichthys cataractae*) Rosyside dace (*Clinostomus funduloides*) Central stoneroller (*Campostoma anomalum*) Common shiner (*Luxilus cornutus*) Northern hogsucker (*Hypentelium nigricans*) * Replaced with Mottled sculpin (*Cottus bairdii*) in Youghiogheny River basin.	- Streams with high instream habitat quality - Streams with high riffle quality - High elevation streams.
		Highland	Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) Longnose dace (*Rhinichthys cataractae*) Fantail darter (*Etheostoma flabellare*) Potomac sculpin (*Cottus girardi*) White sucker (*Catostomus commersonii*)	- Small third-order streams of western MD.

Table 9-4. (Continued)

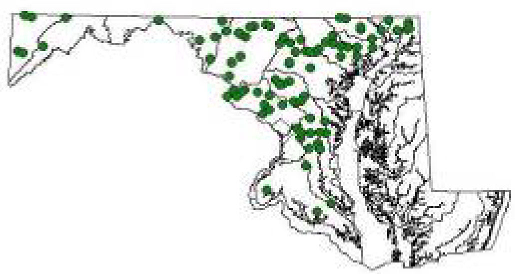
Stream Order	Region	Assemblage	Member Species (present at >=50% of sites)	Characteristics
Third (cont'd)	Non-Coastal Plain (cont'd)	Piedmont	Eastern blacknose dace (*Rhinichthys atratulus*) Creek chub (*Semotilus atromaculatus*) Longnose dace (*Rhinichthys cataractae*) Tessellated darter (*Etheostoma olmstedi*) Redbreast sunfish (*Lepomis auritus*) Bluegill (*Lepomis macrochirus*) Common shiner (*Luxilus cornutus*) White sucker (*Catostomus commersonii*)	- Low elevation Piedmont streams
	Coastal Plain	Coastal Plain	Eastern mudminnow (*Umbra pygmaea*) American eel (*Anguilla rostrata*) Redfin pickerel (*Esox americanus*) Creek chubsucker (*Erimyzon oblongus*) Pirate perch (*Aphredoderus sayanus*) Fallfish (*Semotilus corporalis*) Bluegill (*Lepomis macrochirus*) Least brook lamprey (*Lampetra aepyptera*) Margined madtom (*Noturus insignis*) Pumpkinseed (*Lepomis gibbosus*) Chain pickerel (*Esox niger*) Tessellated darter (*Etheostoma olmstedi*) Largemouth bass (*Micropterus salmoides*) Redbreast sunfish (*Lepomis auritus*) Tadpole madtom (*Noturus gyrinus*) Bluespotted sunfish (*Enneacanthus gloriosus*)	- Numeric dominance of American eel - High species richness

<u>First-Order Stream Fish Assemblages:</u>

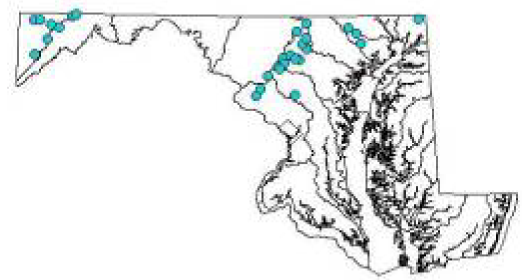
Non-Coastal Plain:



Pioneer Assemblage

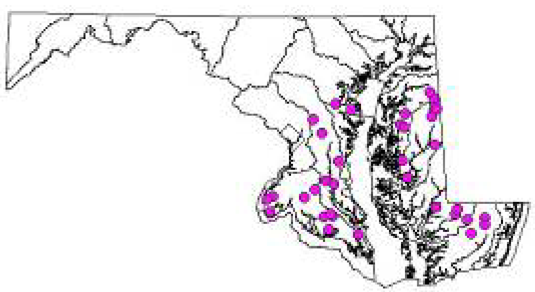


Warmwater Assemblage

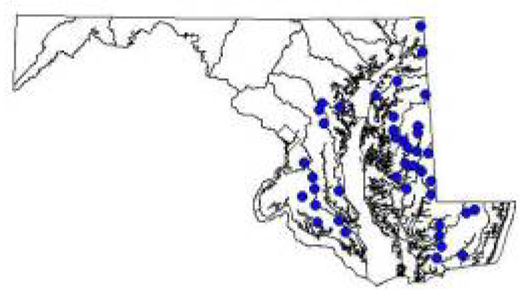


Coldwater Assemblage

Coastal Plain:



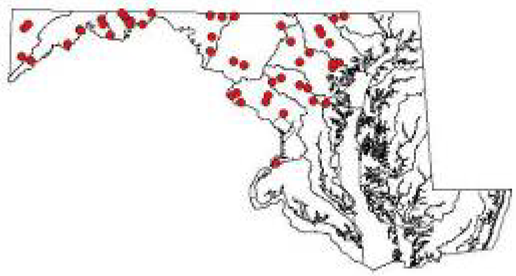
Mudminnow Assemblage



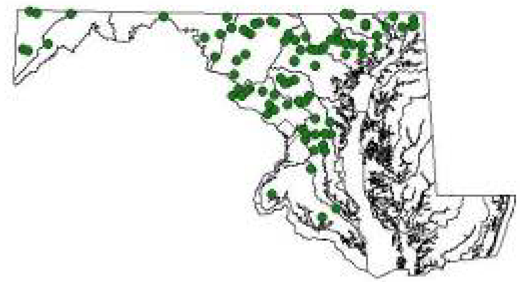
Coastal Assemblage

Figure 9-5. Geographic distributions of sixteen unique stream fish assemblages of Maryland using 1995-1997 MBSS data. Maps are presented by stream order and by region (Non-Coastal Plain and Coastal Plain).

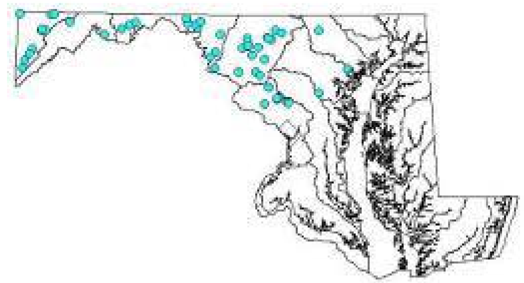
Second-Order Stream Fish Assemblages:
Non-Coastal Plain:



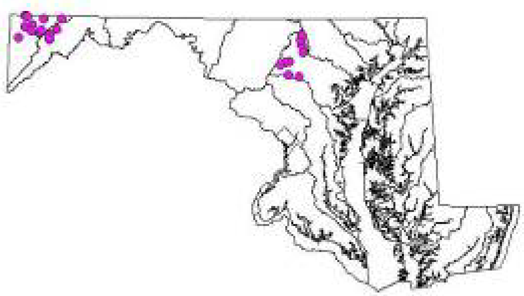
Tolerant Assemblage



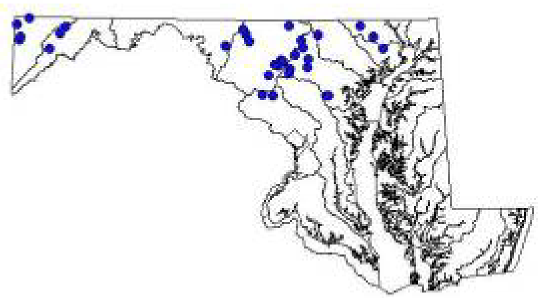
Piedmont Assemblage



Highland Assemblage



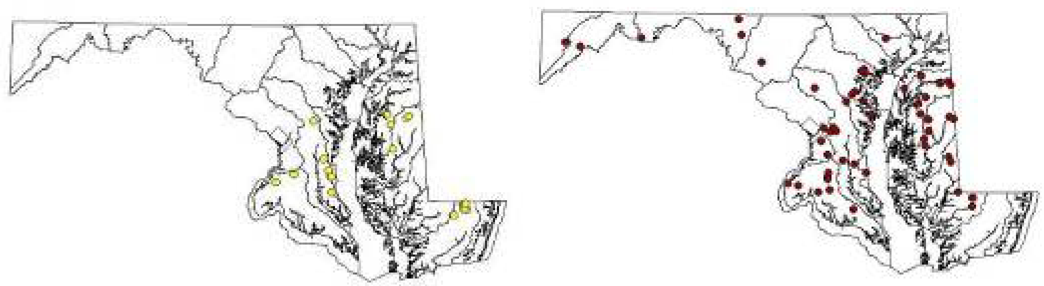
Coldwater Assemblage



Coolwater Assemblage

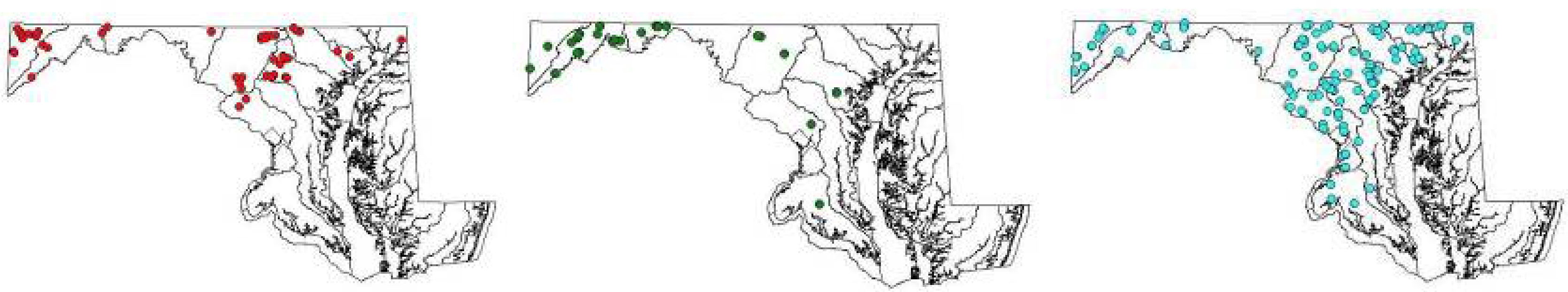
Figure 9-5. (Continued)

Second-Order Stream Fish Assemblages:
Coastal Plain:



Blackwater Assemblage   Coastal Assemblage

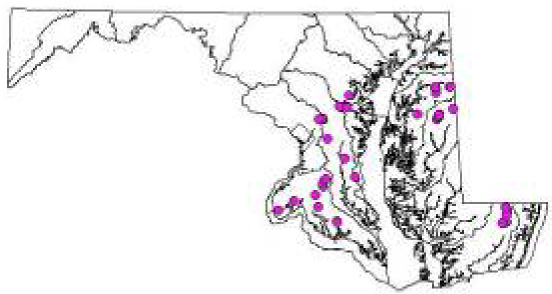
Third-Order Stream Fish Assemblages:
Non-Coastal Plain:



Coolwater Assemblage   Highland Assemblage   Piedmont Assemblage

Figure 9-5. (Continued)

<u>Third-Order Stream Fish Assemblages:</u>
Coastal Plain:



Coastal Plain Assemblage

Figure 9-5. (Continued)

that contain Evolutionarily Significant Units (ESUs), or areas that harbor genetically isolated populations. Danzmann et al. (1998) established that there are a number of genetically unique populations of brook trout in Maryland, including distinct Youghiogheny, Catoctins, and Susquehanna populations. In addition, there is a population of reintroduced brook trout in Jabez Branch in the Severn River drainage that represents the only Coastal Plain population of brook trout in Maryland. Similarly, there is a population of Blue Ridge sculpin in Marshyhope Creek that represents the only known occurrence of *Cottus* in any portion of the Coastal Plain ecoregion (Raesly, 2005 pers. com.). The population of checkered sculpin in Maryland's limestone valleys represents the majority of individuals for the species, and is thus significant from an evolutionary perspective. Similarly, the Maryland population of logperch has been shown to be genetically distinct from populations in other areas and is currently being considered for renaming as a separate species. Each of these units deserves special emphasis in the formulation of management strategies.

9.3.6 Migratory Fishes

With the exception of American eel, most species of migratory (diadromous) fishes in Maryland spend a relatively short but critical period of their lives in non-tidal streams and rivers. However, these are vital to the health of estuarine and near-coastal waters, especially when their historical abundance is considered. For example, American eel may have comprised 50% or more of the biomass in streams within the Chesapeake Bay and Maryland Coastal Bays. In other cases such as American and hickory shad, mortality of post-spawning adults was likely an important source of imported energy.

Because of their proximity to Chesapeake Bay, numerous watersheds are important as spawning and/or nursery areas for migratory fishes such as the herrings, yellow perch, and American eel. Based on MBSS data collected in summer, the watersheds with the highest density of migratory fishes per stream mile on the upper western shore of Chesapeake Bay were Deer Creek and the Lower Susquehanna/Octoraro Creek/Conowingo Dam (Figure 9-6). On the lower western shore, Zekiah Swamp, Magothy River/Severn River, St. Mary's River, and Gilbert Swamp had the highest migratory fish densities. On the eastern shore, the highest densities of migratory fishes were found in the Eastern Bay/Kent Narrows/ Lower Chester River/Langford Creek/Kent Island Bay, Upper Pocomoke River, Nanticoke River, Upper Chester River, and Corsica River/Southeast Creek.

9.4 STREAM HERPETOFAUNA

This chapter provides information about various aspects of biodiversity for reptiles and amphibians for herpetofauna. Amphibians and reptiles were sampled during the summer using different methods for Round 1 (1995-1997) and Round 2 (2000-2004) of the MBSS. In Round 1, searches of the riparian area to 5 m on both sides of the stream were completed; in Round 2, formal searches were not conducted, but any species encountered were recorded. Species encountered during electrofishing were recorded for both rounds. Only species presence was recorded, so no abundance estimates were made. The core MBSS sampling comprised approximately 2,500 probability-based (random) sites on all 1st- through 4th-order nontidal streams in Maryland. Additional targeted sampling has been conducted by the MBSS. Only data on stream-dependent amphibian and reptile species are analyzed in detail. Presence records for other species are valuable, but are in no way comprehensive. Although the focus of the chapter is on stream herpetofauna, some information on other herpetofauna is also presented. The distributions of species, richness, and responses to human disturbance are reported. Additional information about GCN amphibians, species at risk of extirpation or declining precipitously, is shown in Appendix B. The appendix includes information about life history, threats, and conservation actions for each species. In addition, a summary of threats and conservation actions by major

RICHEST HERPETOFAUNA:

Fifteen (15) species of reptiles and amphibians were observed at the MBSS sentinel site on Mattawoman Creek (Charles County) during 2003. Additional second-round sampling at this site has yielded a total of 18 species, including 9 species of frogs and toads and one GCN species, the Eastern hog-nosed snake. With a Combined Biotic Index score of 3.3 and a watershed that is approximately 70% forested, this site represents one of the best Coastal Plain systems in Maryland.

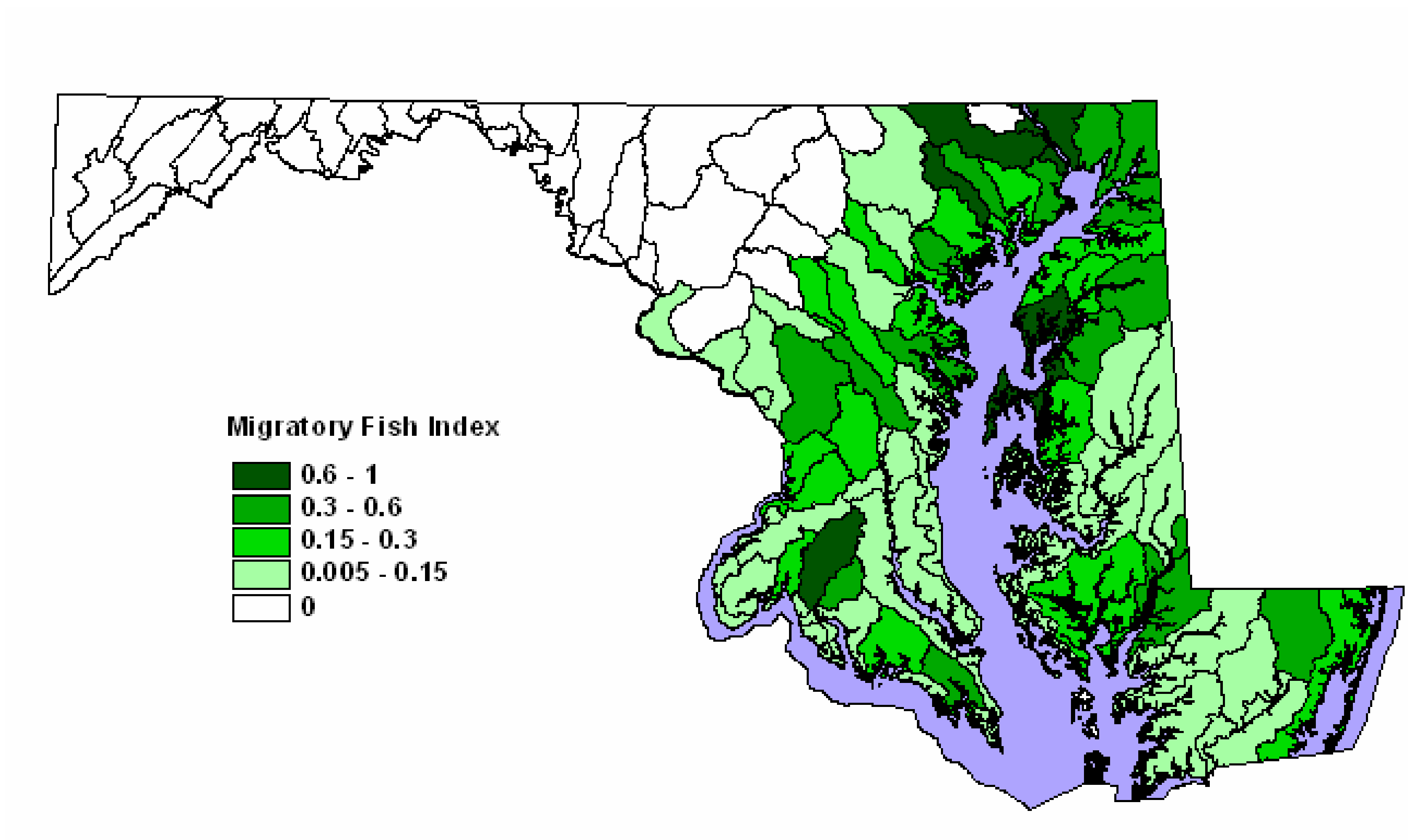


Figure 9-6. Map of watershed rankings for migratory fishes, based on migratory fish densities (per 100 stream miles) observed during the 1995-1997 and 2000-2004 MBSS

habitat type is provided in Maryland's Wildlife Diversity Conservation Plan (http://www.dnr.state.md.us/wildlife/wldivplan.asp).

9.4.1 Species Richness

The MBSS sampled a total of 2,329 sites for amphibians and reptiles from 1994 through 2004. Thirty of the 41 amphibian and 26 of the 49 reptile species and sub-species extant to Maryland were collected in and around stream habitats at these sites (Table 9-5). A total of 56 species of amphibians and reptiles was collected during the 2000-2004 MBSS, eleven more species than the total number (45) collected during the 1995-1997 statewide MBSS. The eleven additional species included the eastern spadefoot (*Scaphiopus holbrooki*), New Jersey chorus frog (*Pseudacris feriarum kalmi*), upland chorus frog (*Pseudacris feriarum feriarum*), green treefrog (*Hyla cinerea*), spotted salamander (*Ambystoma maculatum*), four-toed salamander (*Hemidactylium scutatum*), little brown skink (*Scinella lateralis*), northern red-bellied snake (*Storeria occipitomaculata occipitomaculata*), northern brown snake (*Storeria dekayi dekayi*), northern hognose snake (*Heterodon platyrhinos*), and eastern ribbon snake (*Thamnophis sauritus sauritus*). The addition of species during the second round was most likely due to an improved familiarity of sampling crews with reptile and amphibian habitats. Although mostMBSS reptile and amphibian records (with the exception of stream-dependent salamanders) were based on rapid searches (e.g., 15 minutes) within riparian habitat, MBSS data include records of most of Maryland's amphibian species (73%).

9.4.2 Distribution, with Focus on Stream-Dependent Species

Since sampling by the MBSS was focused solely on stream and riparian areas, distributions of stream-dependent species were effectively characterized using MBSS data. However, additional data were needed to describe the distribution of all amphibians and reptiles found in Maryland. Historical information from Harris (1975) and the MD DNR Natural Heritage Program was used to describe the general distribution (Maryland 6-digit watersheds where they occur) of all amphibians and reptiles believed to be extant (Table 9-5), including species that do not depend on streams and riparian areas.

Eight of Maryland's amphibian species live exclusively in and around streams and depend entirely on these lotic habitats for their reproduction. Maryland's stream-dependent amphibians include the seal salamander (*Desmognathus monticola*), Allegheny mountain dusky salamander (*Desmognathus ochrophaeus*), northern dusky salamander (*Desmognathus fuscus*), long-tailed salamander (*Eurycea longicauda*), northern two-lined salamander (*Eurycea bislineata*), northern spring salamander (*Gyrinophilus porphyriticus porphyriticus*), Eastern mud salamander (*Pseudotriton montanus montanus*), and northern red salamander (*Pseudotriton ruber ruber*).

One of these species, the eastern mud salamander, is found primarily on the Coastal Plain in Maryland (although it has historically been collected on the far eastern portion of the Piedmont). The seal salamander and Allegheny mountain dusky salamander occur only in far western Maryland. The northern spring salamander occurs in mountainous parts of Maryland, and according to Petranka (1998), they typically occur only at altitudes above 100 m. During the 1994-2004 MBSS, spring salamanders were collected only at altitudes above 91m within the Blue Ridge Mountains and throughout Garrett and western Allegany counties. Three species of stream-dependent salamanders, including the northern dusky salamander, long-tailed salamander, and the northern red salamander, were more widespread. These three species were found primarily in the Piedmont and western Maryland, although the northern red salamander was collected and the northern dusky salamander historically existed on portions of the Coastal Plain (Harris 1975). The northern two-lined salamander is the most widely distributed stream-dependent amphibian species in Maryland and can be found throughout the State, with the exception of the lower eastern shore.

9.4.3 Amphibian Response to Human Disturbance

Because relatively few reptiles were collected during the 1994-2004 MBSS, only amphibians were evaluated for their response to human disturbances. However, because amphibian populations are experiencing more rapid declines than other major vertebrate groups (Stuart et al. 2004), the identification of amphibian stressors is particularly important. Worldwide, about 48% of species are declining for unidentified reasons, making the determination of cause and identification of appropriate conservation actions difficult. Semlitsch (2003) grouped threats to amphibians into six categories: habitat destruction and alteration, global warming, chemical contamination, disease and pathogens, invasive species, and commercial exploitation. Amphibians in Maryland could potentially face any one or a combination of these threats.

There were six environmental variables indicative of human influences that appeared to most specifically affect stream salamanders (Figures 9-7 to 9-12). Given the restricted ranges where stream salamanders were found for impervious land cover and nitrate-nitrogen, these two variables appear to be particularly important stressors in Maryland. When each type of human influence was visually combined on an increasing scale, there was a clear decline in species richness with increasing

Table 9-5. List of reptiles and amphibians found in Maryland, with species collected during the 1994-2004 MBSS listed by drainage basin. Historical data from Harris 1975, Thompson 1984, and the Maryland Natural Heritage Program database. Herpetofauna not collected by MBSS are listed as being extant in Maryland, but arenot listed by basin.

Common Name	Scientific Name	YOUGHIOGHENY RIVER	NORTH BRANCH POTOMAC RIVER	UPPER POTOMAC RIVER	ELK RIVER	LOWER SUSQUEHANNA RIVER	GUNPOWDER RIVER	MIDDLE POTOMAC RIVER	CONEWAGO CREEK	PATAPSCO RIVER	BUSH RIVER	PATUXENT RIVER	CHESTER RIVER	WASHINGTON METROPOLITAN	CHOPTANK RIVER	WEST CHESAPEAKE BAY	NANTICOKE RIVER	LOWER POTOMAC RIVER	OCEAN COASTAL	POCOMOKE RIVER
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*																			
Jefferson Salamander	*Ambystoma jeffersonianum*													S						
Marbled Salamander	*Ambystoma opacum*		S	1	S	S	S	S		2	S	1	S	2	S	2	S	2		S
Spotted Salamander	*Ambystoma maculatum*	S	S	S	S	S	2	S		2	S	2	S	2	S	S		2		
Eastern Hellbender	*Cryptobranchus alleganiensis alleganiensis*																			
Common Mudpuppy	*Necturus maculosus maculosus*																			
Allegheny Mountain Dusky Salamander	*Desmognathus ochrophaeus*	X	X																	
Northern Dusky Salamander	*Desmognathus fuscus*	X	X	X	X	X	X	X		X	1	X		X	1	1		X		
Seal Salamander	*Desmognathus monticola*	1	X																	
Long-tailed Salamander	*Eurycea longicauda longicauda*	1	1	X		2	X	1		X				2						
Northern Two-Lined Salamander	*Eurycea bislineata*	X	X	X	X	X	X	X		X	X	X	X	X	X	X	S	X		1
Northern Spring Salamander	*Gyrinophilus porphyriticus porphyriticus*	X	X	X				X		1				2						
Eastern Mud Salamander	*Pseudotriton montanus montanus*			1								1		1		1		1		
Northern Red Salamander	*Pseudotriton ruber ruber*	1	X	X	2	X	X	X		X	2	X	S	X	S	X		X		
Four-toed Salamander	*Hemidactylium scutatum*	S	S	S		S	S			S	S	S	S	S		2	S	S		S
Green Salamander	*Aneides aeneus*																			
Eastern Red-backed Salamander	*Plethodon cinereus*	1	1	S	2	X	2	1		X	S	X	S	X	S	S	S	1	S	S
Northern Slimy Salamander	*Plethodon glutinosus*	1	X	X		S	S	1		2	S	S		S						

Table 9-5. (Continued)

Common Name	Scientific Name	YOUGHIOGHENY RIVER	NORTH BRANCH POTOMAC RIVER	UPPER POTOMAC RIVER	ELK RIVER	LOWER SUSQUEHANNA RIVER	GUNPOWDER RIVER	MIDDLE POTOMAC RIVER	CONEWAGO CREEK	PATAPSCO RIVER	BUSH RIVER	PATUXENT RIVER	CHESTER RIVER	WASHINGTON METROPOLITAN	CHOPTANK RIVER	WEST CHESAPEAKE BAY	NANTICOKE RIVER	LOWER POTOMAC RIVER	OCEAN COASTAL	POCOMOKE RIVER
Valley and Ridge Salamander	*Plethodon hoffmani*		S	S																
Wehrle's Salamander	*Plethodon wehrlei*																			
Red-spotted Newt	*Notopthalamus viridescens viridescens*	X	X	X	S	S	S	S		S		1	S	2	S	S	S	X		
Eastern American Toad	*Bufo americanus americanus*	1	X	X	X	X	X	X		X	X	X	2	X	2	2	S	X	S	S
Fowler's Toad	*Bufo fowleri*	S		X	2	X	2	X		X	2	X	X	2	X	X	2	X	2	X
Eastern Narrow-mouthed Toad	*Gastrophryne carolinensis*																			
Eastern Spadefoot	*Scaphiopus holbrookii*												2		2			2		
American Bullfrog	*Rana catesbeiana*	1	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	2	X
Carpenter Frog	*Rana virgatipes*																			
Northern Green Frog	*Rana clamitans melanota*	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	2	X
Northern Leopard Frog	*Rana pipiens*	S		S		S	S	S		S				1		1				
Pickerel Frog	*Rana palustris*	1	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X
Southern Leopard Frog	*Rana sphenocephala utricularia*				2		S			2	2	X	X	2	X	X	X	X	2	X
Wood Frog	*Rana sylvatica*	1	X	X	2	X	X	X		X	2	X	2	X	X	1		X	2	X
Barking Treefrog	*Hyla gratiosa*																			
Cope's Gray and Gray Treefrog	*Hyla chrysoscelis* and *H. versicolor*		S	S	S	2	S	S		2	2	X	2	2	S	S	2	2	S	2
Green Treefrog	*Hyla cinerea*				S		S			S	S	2	S	S	2	S	S	S	S	S
Mountain Chorus Frog	*Pseudacris brachyphona*																			
New Jersey Chorus Frog	*Pseudacris feriarum kalmi*																2			
Northern Spring Peeper	*Pseudacris crucifer crucifer*	X	S	1	S	2	1	X		2	X	X	X	X	X	X	X	2	2	S
Upland Chorus Frog	*Pseudacris feriarum feriarum*		S	S		S	S	S		S	S	S		S		S		2		
Northern Cricket Frog	*Acris crepitans crepitans*		S	S	S	S	S	S		S	2	X	S	S	S	S	S	X		S

Table 9-5. (Continued)

Common Name	Scientific Name	YOUGHIOGHENY RIVER	NORTH BRANCH POTOMAC RIVER	UPPER POTOMAC RIVER	ELK RIVER	LOWER SUSQUEHANNA RIVER	GUNPOWDER RIVER	MIDDLE POTOMAC RIVER	CONEWAGO CREEK	PATAPSCO RIVER	BUSH RIVER	PATUXENT RIVER	CHESTER RIVER	WASHINGTON METROPOLITAN	CHOPTANK RIVER	WEST CHESAPEAKE BAY	NANTICOKE RIVER	LOWER POTOMAC RIVER	OCEAN COASTAL	POCOMOKE RIVER
Stinkpot	*Sternotherus odoratus*	S	S	2	2	S	S	S		2	2	1	X	S	X	1	2	X	S	X
Eastern Mud Turtle	*Kinosteron subrubrum subrubrum*				S	S	S	S		S	S	X	1	S	2	S	2	2	S	S
Eastern Box Turtle	*Terrapene carolina carolina*	S	X	X	X	X	2	X		X	X	X	X	X	2	X	X	X	S	1
Spotted Turtle	*Clemmys guttata*	S	S	S	S	S	S	1		S	S	S	S	1	S	S	S	X		S
Bog Turtle	*Glyptemys muhlenbergii*				S	S	S				S									
Wood Turtle	*Glyptemys insculpta*	S	X	X	S	1	S	S		S	S			S				1		
Northern Diamondback Terrapin	*Malaclemys terrapin terrapin*				S		S				S	S	S		S	S	S	S		S
Northern Map Turtle	*Graptemys geographica*				S	S				S					S					
Midland and Eastern Painted Turtle	*Chrysemys picta marginata* and *C. picta picta*	S	S	2	1	2	2	1		2	2	X	X	X	X	1	X	X	2	X
Red-eared slider	*Trachemys scripta elegans*			S			S	S		S	S	S		S		S				
Northern Red-bellied Cooter	*Pseudemys rubriventris*		S		S	S	S	S		S	S	2	2	2	S	S	1		S	S
Eastern Snapping Turtle	*Chelydra serpentina serpentina*	X	S	X	X	X	X	X		X	X	X	X	X	X	X	X	X	2	X
Eastern River Cooter	*Pseudemys concinna concinna*																			
Eastern Spiny Softshell	*Apalone spinifera spinifera*	S																		
Eastern Fence Lizard	*Sceloporus undulatus*		S	X	S	S	S	S		S		2	S	S	S	S	S	2	S	2
Eastern Six-lined Racerunner	*Aspidoscelis sexlineatus sexlineatus*			S				S		S		S		S		S		S		
Little Brown Skink	*Scincella lateralis*									S		S		S	S	S	S	2		2
Northern Coal Skink	*Plestiodon anthracinus anthracinus*	S		S																
Common Five-lined Skink	*Plestiodon fasciatus*	S		X	S	S	S	S		S	2	2	X	2	X	1	2	X	S	S
Broadhead Skink	*Plestiodon laticeps*			S		S	S		S		S	S	S	S	S	S	S	S	S	
Southeastern Five-lined Skink	*Plestiodon inexpectatus*											1			1	S				

Table 9-5. (Continued)

Common Name	Scientific Name	YOUGHIOGHENY RIVER	NORTH BRANCH POTOMAC RIVER	UPPER POTOMAC RIVER	ELK RIVER	LOWER SUSQUEHANNA RIVER	GUNPOWDER RIVER	MIDDLE POTOMAC RIVER	CONEWAGO CREEK	PATAPSCO RIVER	BUSH RIVER	PATUXENT RIVER	CHESTER RIVER	WASHINGTON METROPOLITAN	CHOPTANK RIVER	WEST CHESAPEAKE BAY	NANTICOKE RIVER	LOWER POTOMAC RIVER	OCEAN COASTAL	POCOMOKE RIVER
Northern Watersnake	*Nerodia sipedon sipedon*	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	2	X
Red-bellied Watersnake	*Nerodia erythrogaster erythrogaster*														S	S	S			S
Queen Snake	*Regina septemvittata*	1	S	1	S	S	2	2		X	2	2	2	1		2				
Eastern Smooth Earthsnake	*Virginia valeriae valeriae*			1	S	S	S	S		S		S	S	S		2	S	S		S
Mountain Earthsnake	*Virginia valeriae pulchra*	S																		
Northern Brownsnake	*Storeria dekayi dekayi*	S	S	S	S	S	S	S		S	S	S	X	2	S	S	S	S	S	S
Northern Red-bellied Snake	*Storeria occipitomaculata occipitomacculata*	S	S	S	S			S		S		S	S	S		2	S	S		S
Eastern Gartersnake	*Thamnophis sirtalis sirtalis*	X	1	X	S	X	2	X		X	X	2	S	X	2	S	S	2	S	S
Common Ribbonsnake	*Thamnophis sauritus sauritus*		S	S	S	S	S	2		S	S	S	S	S	S	S	S	S	S	S
Southern and Northern Ring-necked Snake	*Diadophis punctatus punctatus* and *D. punctatus edwardsii*	S	1	1	1	2	1	S		X	S	X	2	X	2	S	S	X	S	S
Eastern Wormsnake	*Carphophis amoenus amoenus*		S	1	S	S	S	S		S		X	S	2	S	2	S	X	2	S
Smooth Greensnake	*Opheodrys vernalis*	1	S	S				S												
Rough Greensnake	*Opheodrys aestivus*			S	S	S	S			S		2	S	2	X	S	S	2	S	S
Eastern Hog-nosed Snake	*Heterodon platirhinos*	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S	S	S	S
Common Rainbow Snake	*Farancia erytrogramma erytrogramma*													S				S		
Northern Black Racer	*Coluber constrictor constrictor*	S	S	S	S	S	S	S		S		1	2	S	X	1	2	X		1
Northern Pine Snake	*Pituophis melanoleucus melanoleucus*									S		S	S			S			S	S
Red Cornsnake	*Elaphe guttata*			S			S			S		S		S	S	S	S	S		S
Eastern Ratsnake	*Elaphe alleghaniensis*	S	X	2	S	1	S	2		2	2	X	2	X	1	S	2	X	S	X

Table 9-5. (Continued)

Common Name	Scientific Name	YOUGHIOGHENY RIVER	NORTH BRANCH POTOMAC RIVER	UPPER POTOMAC RIVER	ELK RIVER	LOWER SUSQUEHANNA RIVER	GUNPOWDER RIVER	MIDDLE POTOMAC RIVER	CONEWAGO CREEK	PATAPSCO RIVER	BUSH RIVER	PATUXENT RIVER	CHESTER RIVER	WASHINGTON METROPOLITAN	CHOPTANK RIVER	WEST CHESAPEAKE BAY	NANTICOKE RIVER	LOWER POTOMAC RIVER	OCEAN COASTAL	POCOMOKE RIVER
Mole Kingsnake	*Lampropeltis calligaster rhombomaculata*									S		S		S		S		S		
Eastern Kingsnake	*Lampropeltis getula getula*				S	S	S			S	S	S	S	S	S	S	S	S	S	S
Eastern Milk Snake	*Lampropeltis triangulum triangulum*	S	S	S	S	S	S	S		S	S	S		S						
Coastal Plain Milk Snake	*Lampropeltis triangulum temporalis*				S					S		S		S		S		S	S	S
Northern Scarlet Snake	*Cemophora coccinea copei*													S			S	S		
Northern and Southern Copperhead	*Agkistrodon contortrix mokasen* and *A. contortrix contortrix*	S	S	S	S	S	1	S		S		X		S		S	S	2	S	S
Timber Rattlesnake	*Crotalus horridus*	S	S	S			S	S												

X Observed during both Rounds 1 and 2
1 Observed only during Round 1 or during 1994 sampling
2 Observed only during Round 2
S Observed only in Supplemental Data (historic data)

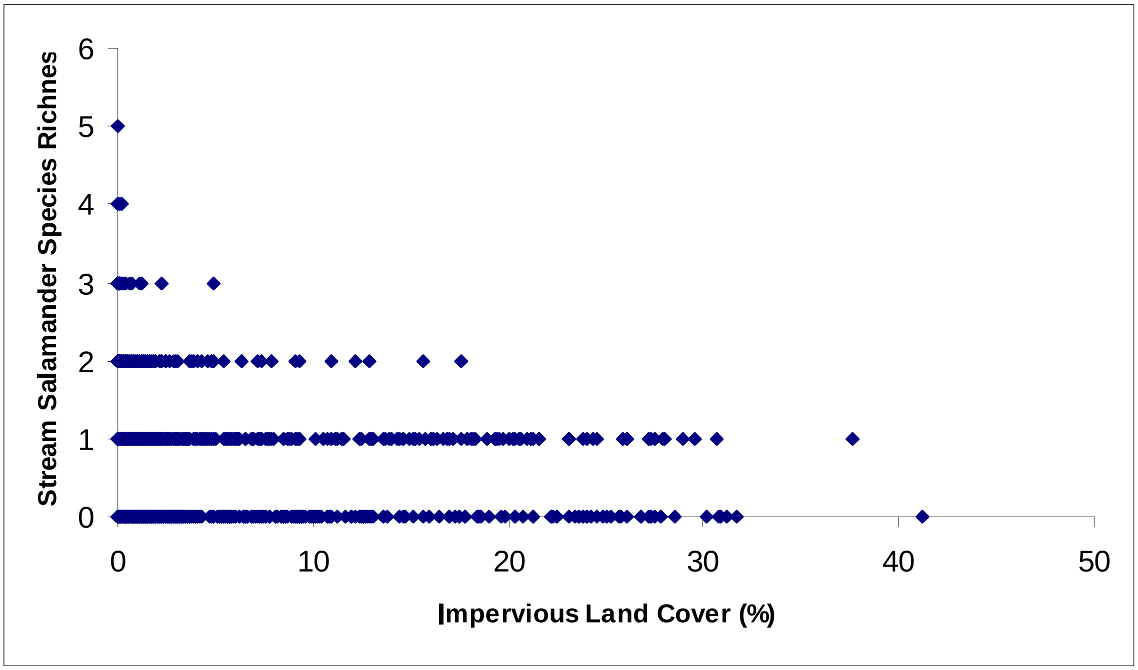


Figure 9-7. Stream salamander species richness versus impervious land cover at MBSS 1994-2004 sites

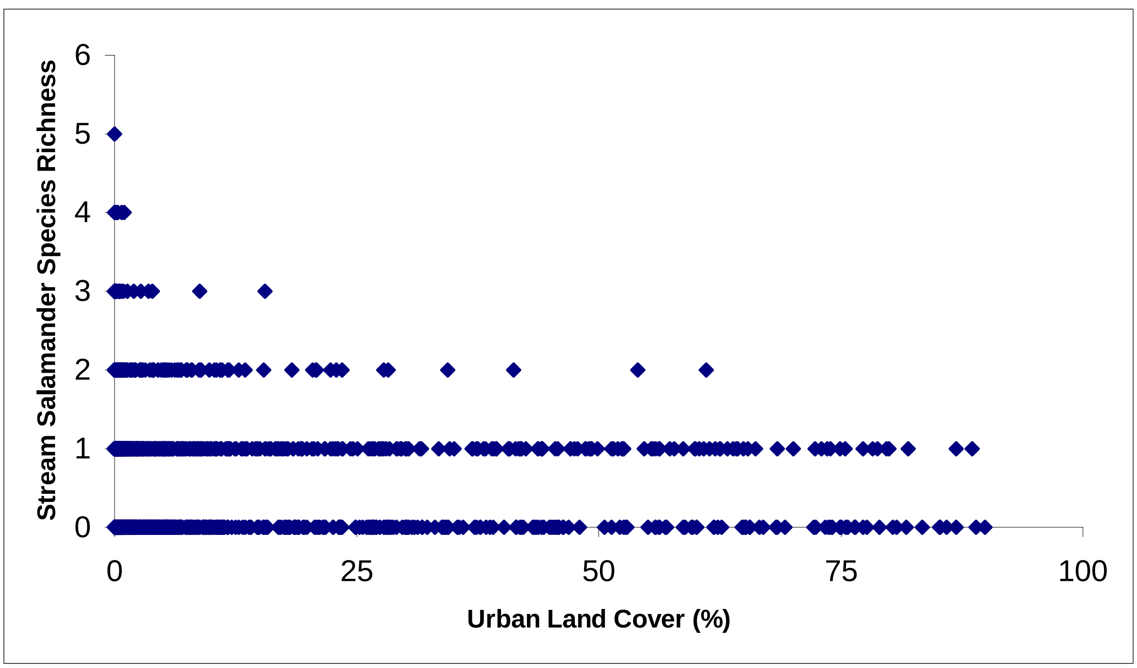


Figure 9-8. Stream salamander species richness versus urban land cover at MBSS 1994-2004 sites

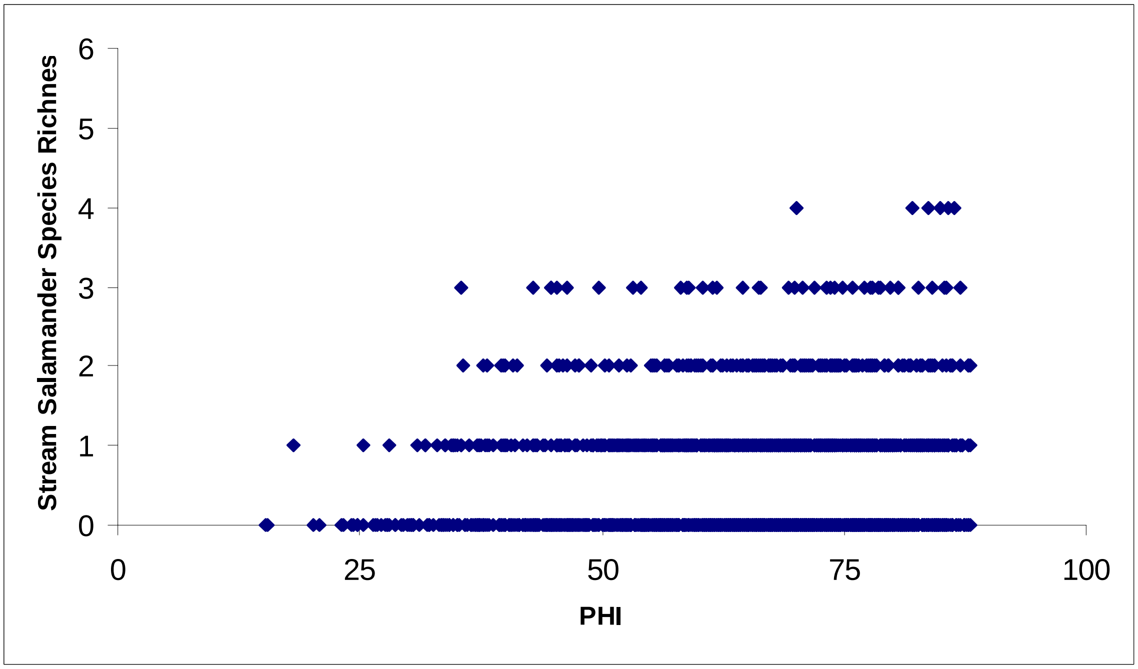


Figure 9-9. Stream salamander species richness versus Physical Habitat Index score at MBSS 1994-2004 sites

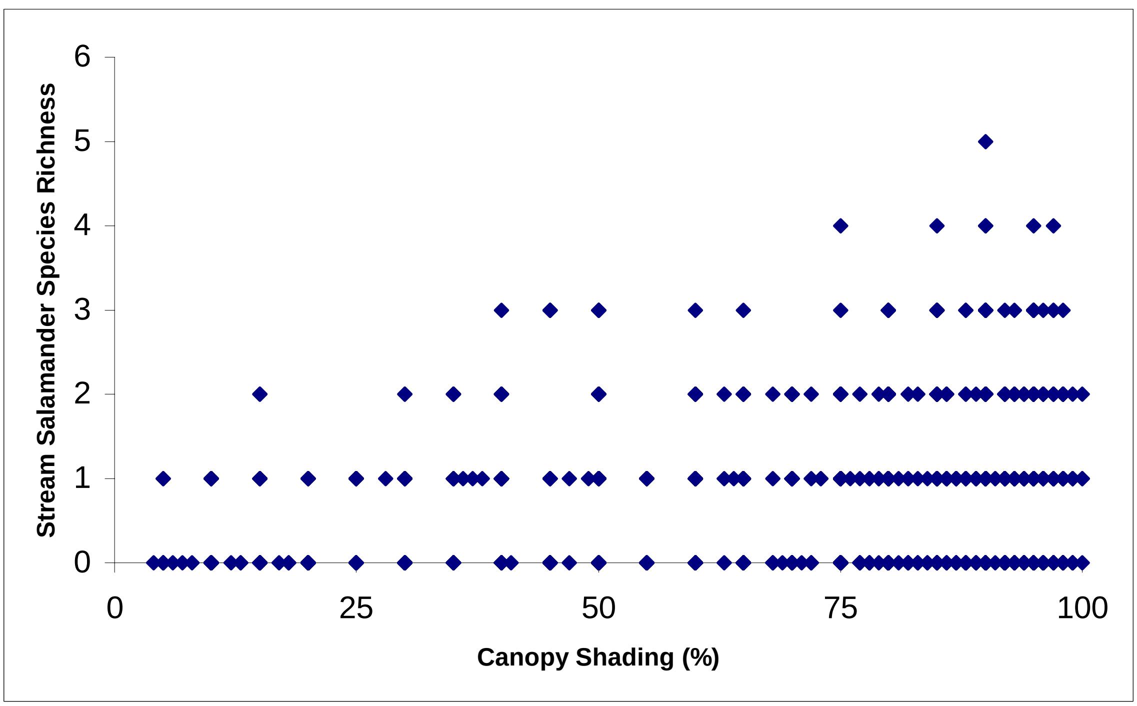


Figure 9-10. Stream salamander species richness versus canopy shading at MBSS 1994-2004 sites

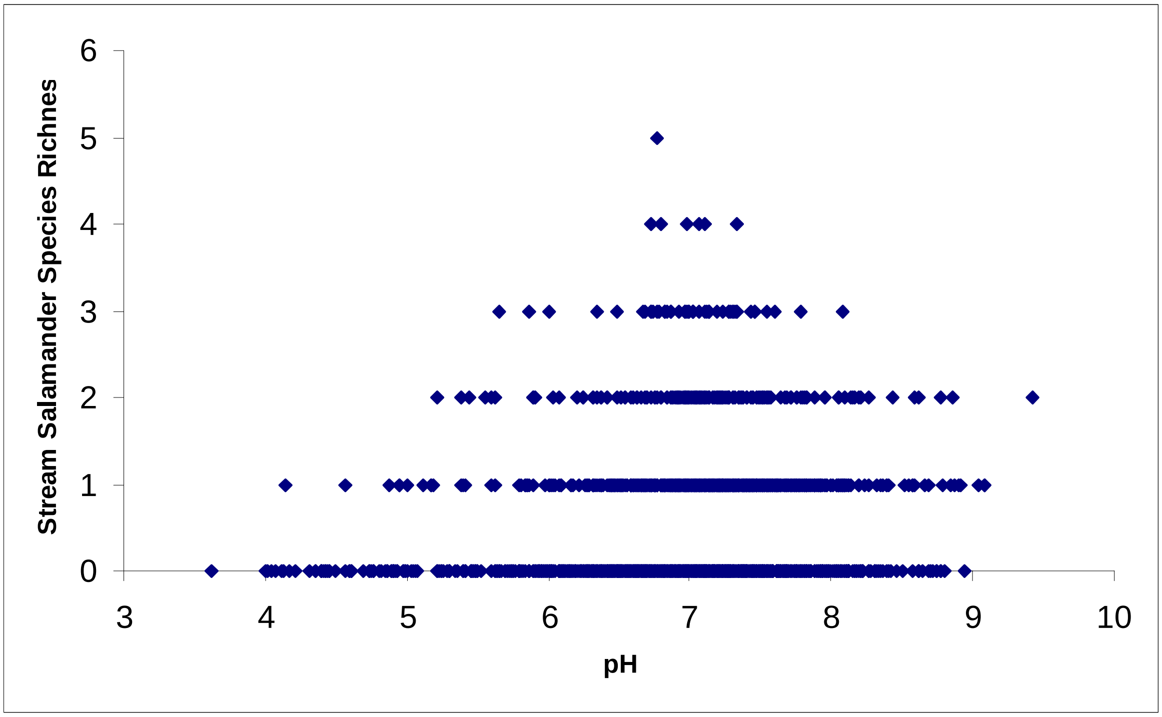


Figure 9-11. Stream salamander species richness versus pH at MBSS 1994-2004 sites

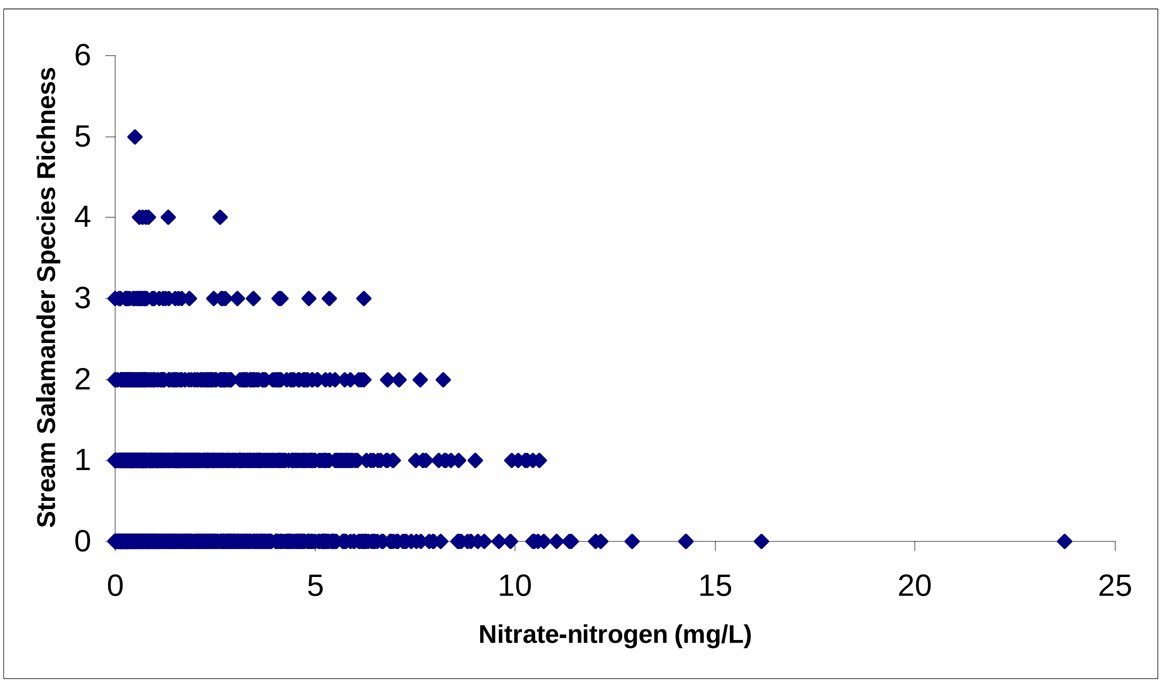


Figure 9-12. Stream salamander species richness versus nitrate-nitrogen at MBSS 1994-2004 sites

disturbance (Figure 9-13). The northern two-lined salamander was the only stream-dependent salamander species found in highly disturbed streams. In contrast, the seal salamander was only found in streams with little disturbance. Although Figure 9-13 demonstrates general thresholds of human disturbance, each species responds differently to individual disturbance types (Figure 9-14).

For example, northern two-lined salamander was found in streams with high levels of urbanization, imperviousness, and physical habitat degradation. Three other species, northern red, Allegheny mountain dusky, and northern dusky salamanders, were collected by MBSS in streams with substantially lower pH (as low as 4.2) than any site where northern two-lined salamander was collected (minimum pH - 5.1).

The six disturbance indicators were also visually related to amphibian species richness (Figures 9-15 to 9-20). Richness never exceeded five species at any MBSS site rated as severely disturbed (as defined in Figure 9-13). However, a total of 9 species, including American toad (*Bufo americanus americanus*), Fowler's toad (*Bufo fowleri*), bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans melenota*), pickerel frog (*Rana palustrus*), southern leopard frog (*Rana sphenocephela utricularius*), wood frog (*Rana sylvatica*), northern spring peeper (*Pseudacris crucifer*), eastern red-backed salamander (*Plethodon cinereus*), and northern two-lined salamander (*Eurycea bislineata*) were collected from severely disturbed MBSS sites. All of these species are ubiquitous in Maryland and were collected at many sampling sites.

As imperviousness and urbanization appear to be important stressors to amphibians in Maryland, increasing levels of development pose a threat to the conservation of this assemblage. From 1973 to 2000, the percentage of urban land use in Maryland increased substantially in a number of watersheds, including those with GCN species (Table 9-6). High levels of development also occurred in watersheds that represent the last remaining strongholds for one or more species.

It is important to note that types of human disturbance, not evaluated here, may influence herpetofauna. For example, many Maryland herpetofauna use downed trees, logs, and other cover for protection from predation and desiccation during some portion of their life cycle. Thus, logging and/or the removal of dead or dying trees from forested areas pose a threat to survival of some species. In Oregon, Hughes et al. (2004) found logging and road building to be important stressors for stream salamanders. Stocking predatory fishes in streams may also be detrimental, as most amphibian larvae are susceptible to fish predation. There is also a growing body of literature on the effects of chemicals such as atrazine on amphibians (Hayes et al. 2002; USEPA 2003; Relyea 2005). A recent summary of the sensitivity of Appalachian benthos to various stressors is provided in Yuan and Norton (2005).

9.5 STREAM BENTHIC MACROINVERTEBRATES

This chapter summarizes information on the biodiversity of benthic macroinvertebrates in Maryland streams, with discussions of major taxonomic groups. Benthic macroinvertebrates were sampled during the spring using 20 "jabs" of 600-micron D nets to collect organisms from 2.0 m^2. Organisms were collected from habitats likely to support the greatest taxonomic diversity (e.g., riffles, rootwads, woody debris, leaf packs, macrophytes, and undercut banks). There are sections on distribution and relative abundance, key habitats and associated communities, and responses of benthos to human disturbance.

9.5.1 Overview

In general, little is known about benthic macroinvertebrate biodiversity in streams, including those in Maryland. Allan & Flecker (1993) stated that the incomplete knowledge base of biological diversity and distributional patterns of invertebrates in freshwater rivers and streams might mask a potential biodiversity crisis. Reasons for this lack of knowledge include difficulties associated with identification of immature specimens to species, as well as the very large numbers of organisms found in relatively small areas.

Most of the MBSS benthic data discussed in this section were collected from 1st through 4th order streams at 2,386 sites throughout the State between 1994 and 2004. The large spatial scale of the dataset spans Maryland's ecoregions from the cold, high gradient streams on the Appalachian Plateau to the slow moving, blackwater streams on the Delmarva Peninsula. Organisms were collected from best available habitat, sortate was subsampled to achieve a target of 100 organisms per sample, and most individuals were identified to genus. Because of the lack of quantitative, species-level information, the use of MBSS benthic data to describe benthic biodiversity was limited to a presentation of relative abundance and genus-level distribution. However, because very little has been previously described about benthic macroinvertebrate biodiversity in Maryland, the analyses presented in this chapter are a significant contribution to the state of knowledge.

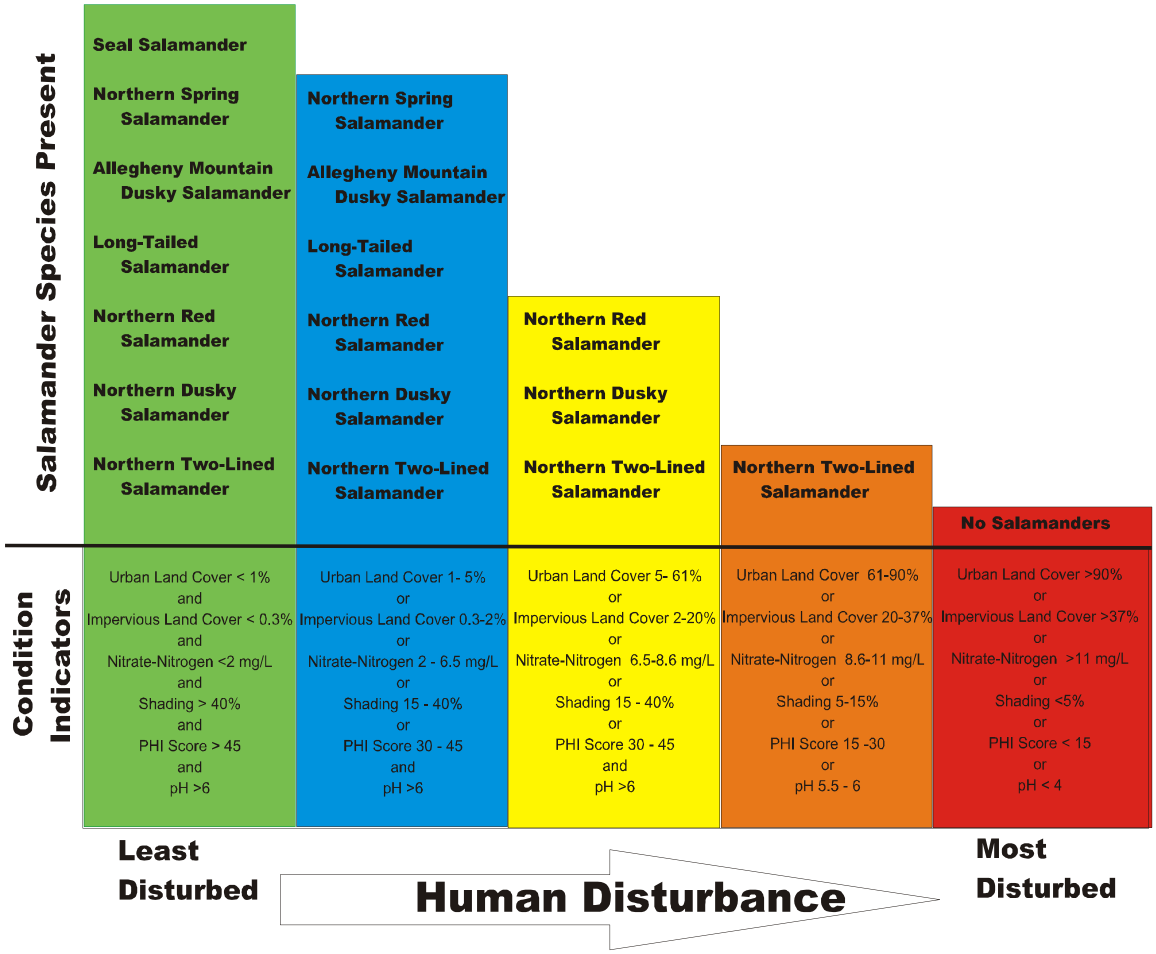


Figure 9-13. Stream salamander occurrences at varying levels of human disturbance, based on 1994-2004 MBSS data

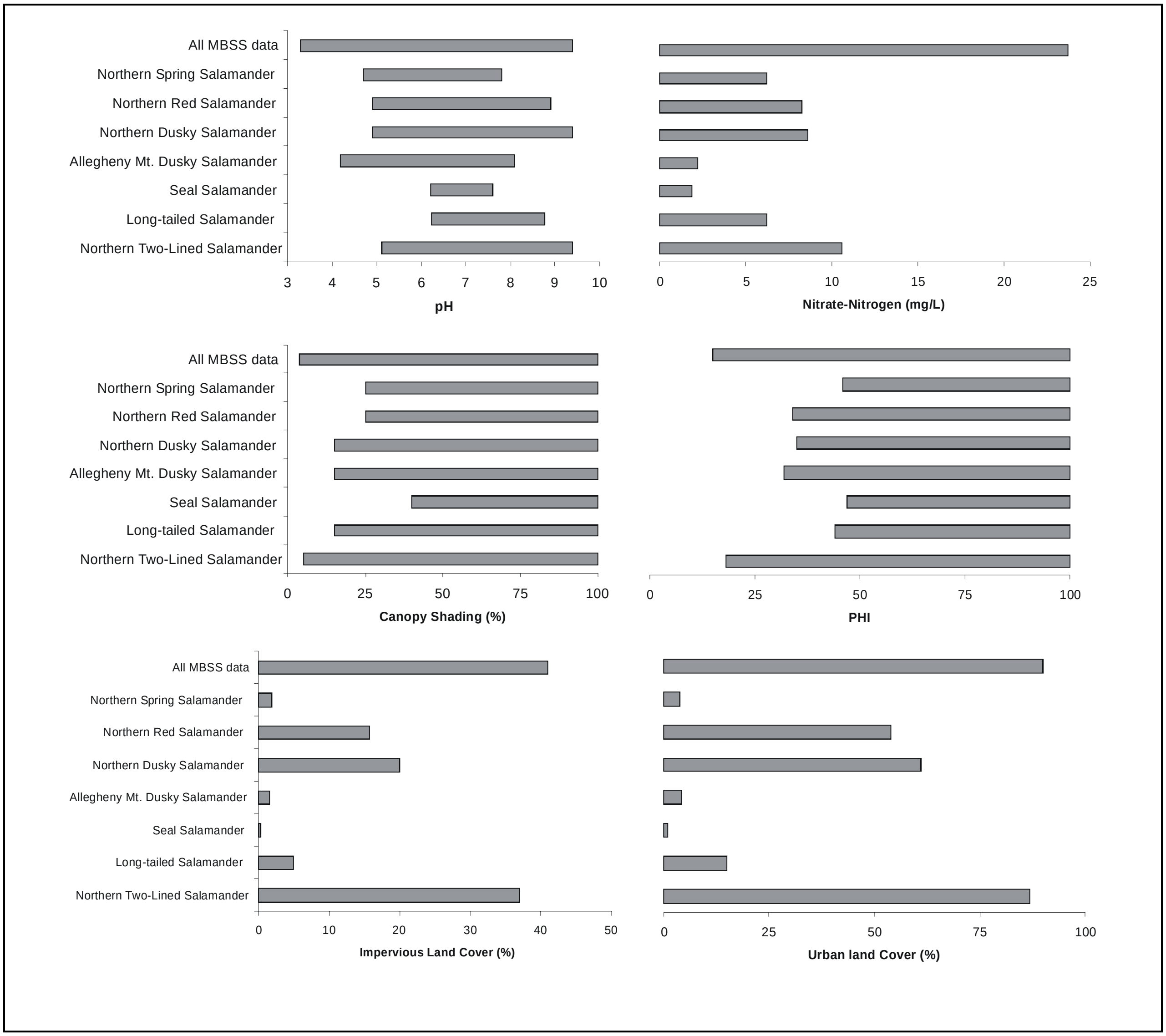


Figure 9-14. Range of values where the stream salamander species were found concomitant with six measures of human influence, based on 1994-2004 MBSS sites

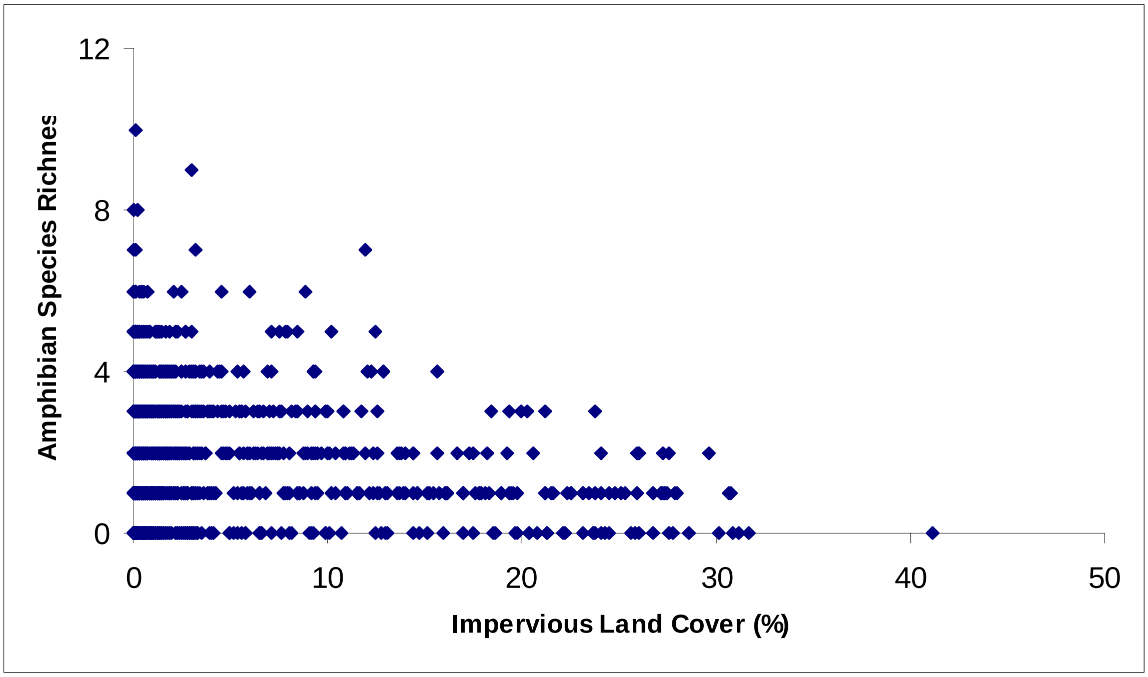


Figure 9-15. Amphibian species richness versus impervious land cover at MBSS 1994-2004 sites

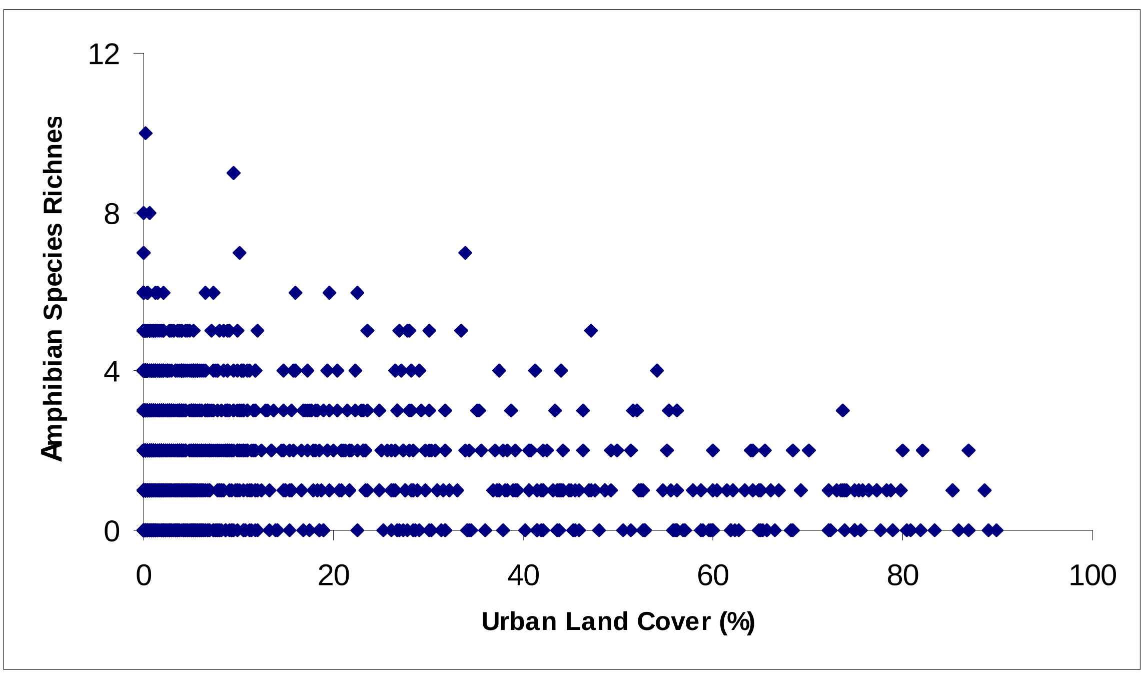


Figure 9-16. Amphibian species richness versus percent urban land cover at MBSS 1994-2004 sites

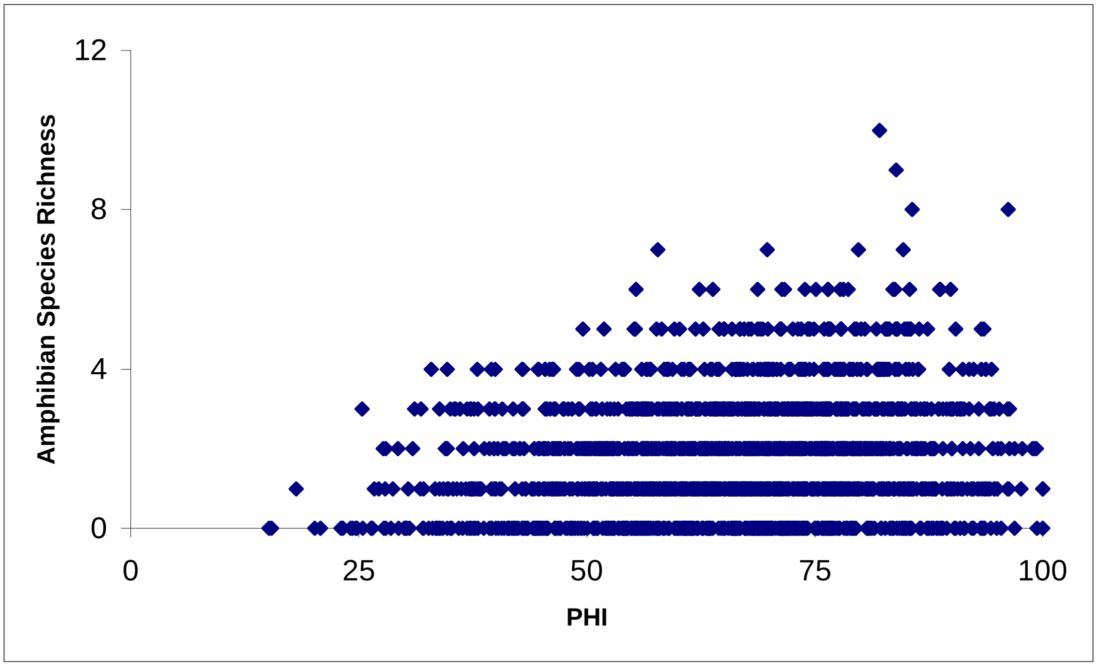


Figure 9-17. Amphibian species richness versus Physical Habitat Index score at MBSS 1994-2004 sites

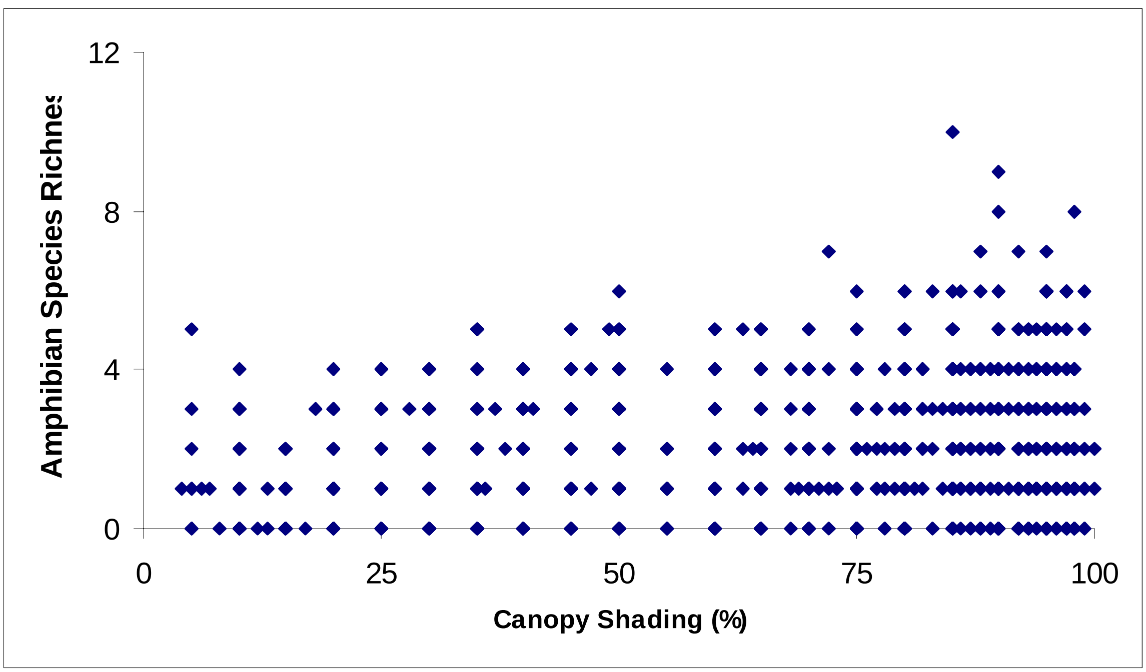


Figure 9-18. Amphibian species richness versus percent canopy shading at MBSS 1994-2004 sites

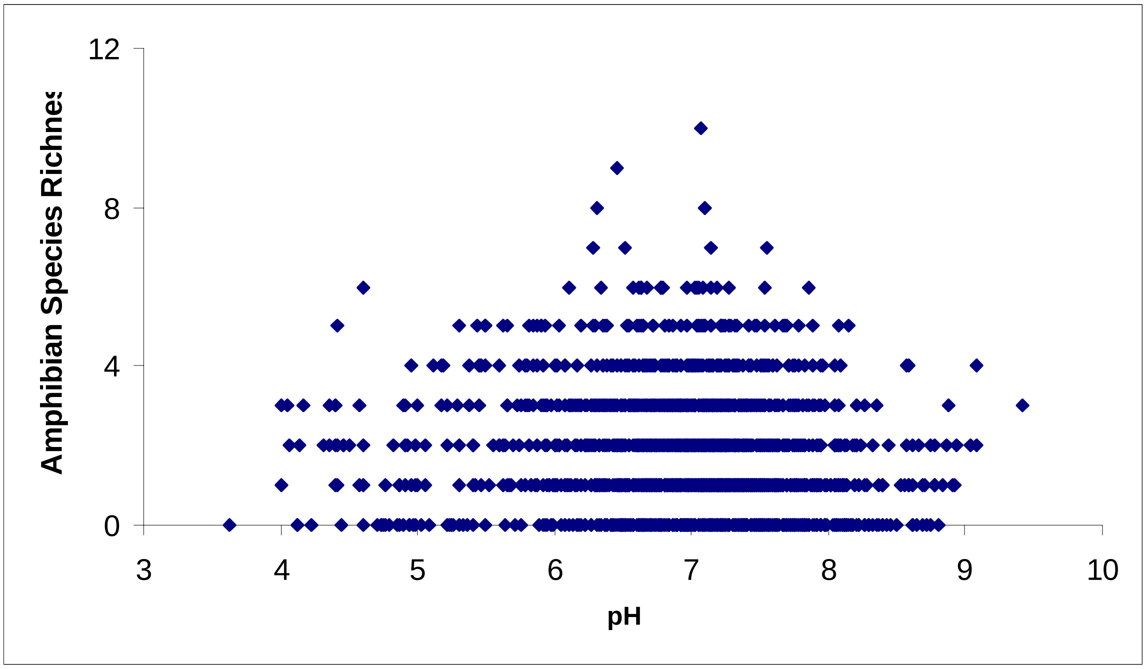


Figure 9-19. Amphibian species richness versus pH at MBSS 1994-2004 sites

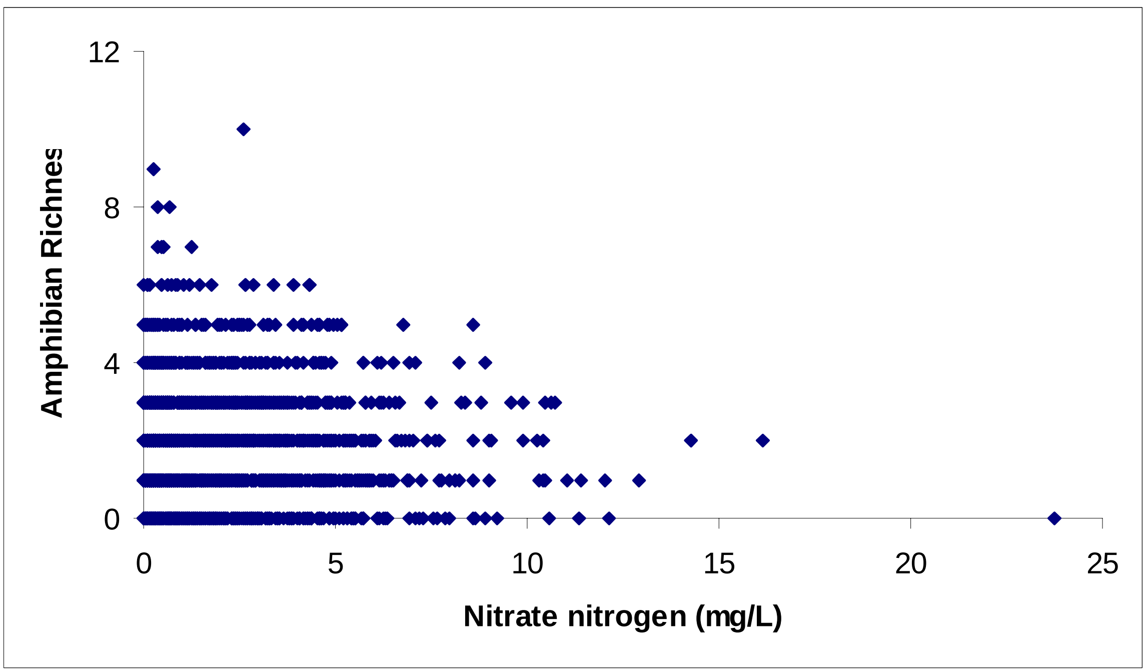


Figure 9-20. Amphibian species richness versus nitrate-nitrogen at MBSS 1994-2004 sites

Table 9-6. Land use change in Maryland watersheds, 1973-2000 (data from Maryland Dept. of Planning)

Watershed	1973 (%)			2000 (%)			% Change Urban
	Agriculture	Forest	Urban	Agriculture	Forest	Urban	
Anacostia River	11.8	32.4	55.0	2.4	16.6	78.6	23.6
Antietam Creek	62.6	27.9	9.4	48.5	28.6	22.7	13.3
Atkisson Reservoir	52.7	33.5	13.6	39.5	26.0	34.1	20.5
Big Elk Creek	51.8	41.8	6.2	47.6	39.5	12.5	6.3
Bohemia River	66.1	21.0	1.2	63.9	21.1	3.2	2.0
Breton Bay	26.4	60.3	4.6	23.0	54.3	13.4	8.8
Brighton Dam	62.1	33.0	2.9	49.4	33.5	15.1	12.2
Broad Creek	60.8	36.2	2.7	54.6	33.8	11.2	8.5
Bush River	19.6	42.1	14.6	16.0	37.9	20.6	6.0
Bynum Run	43.8	33.8	22.6	23.0	23.5	53.2	30.6
Cabin John Creek	2.4	22.8	74.5	0.8	12.6	86.5	12.0
Casselman River	27.0	69.3	2.2	25.4	65.8	7.3	5.1
Catoctin Creek	64.9	32.8	2.3	53.7	34.9	11.4	9.1
Chester River Lower	26.7	15.0	2.3	26.2	12.9	4.9	2.6
Chester River Middle	73.9	13.2	4.5	71.5	11.9	8.3	3.8
Chester River Upper	63.6	33.3	1.3	63.7	30.9	3.3	2.0
Choptank River Upper	59.6	32.0	2.8	57.4	28.4	8.2	5.4
Conococheague Creek	72.2	17.8	8.9	54.0	19.5	24.9	16.0
Corsica River	62.9	28.6	2.7	60.4	26.8	6.9	4.2
Deep Creek Lake	23.1	61.3	5.5	19.8	48.5	19.6	14.1
Deer Creek	62.0	34.1	4.0	55.5	31.8	12.4	8.4
Dividing Creek	19.7	79.6	0.0	20.1	77.5	1.7	1.7
Double Pipe Creek	78.5	17.0	4.4	68.9	19.3	11.7	7.3
Elk River Upper	23.4	51.2	12.4	15.7	46.1	25.2	12.8
Fifteen Mile Creek	5.7	94.4	0.0	5.4	92.6	2.0	2.0
Furnace Bay	46.8	43.8	5.6	40.3	41.4	14.3	8.7
Gilbert Swamp	38.3	59.4	1.4	33.2	52.5	13.1	11.7
Gunpowder River	4.5	25.8	19.5	2.6	23.8	22.6	3.1
Isle of Wight Bay	35.5	34.3	8.3	30.2	29.0	19.3	11.0
Little Conococheague River	58.2	40.1	1.5	48.0	40.9	10.9	9.4
Little Gunpowder Falls	52.0	35.2	12.3	42.5	32.7	24.0	11.7
Little Patuxent River	26.0	45.3	28.3	12.7	37.0	49.8	21.5
Little Youghiogheny River	45.1	44.4	7.6	41.1	41.8	16.3	8.7
Wicomico River Lower	34.1	38.0	10.0	28.0	32.2	21.5	11.5
Winters Run Lower	28.8	50.4	18.5	16.2	40.2	40.8	22.3
Manokin River	24.9	37.6	1.4	23.5	36.5	4.6	3.2
Marsh Run	74.3	15.6	10.2	56.6	19.5	23.8	13.6
Marshyhope Creek	53.6	39.4	2.2	52.9	36.6	5.7	3.5
Mattawoman Creek	15.7	68.4	12.1	12.0	58.1	25.7	13.6
Middle Patuxent River	55.2	37.5	7.2	36.3	28.5	35.0	27.8
Monocacy River Lower	64.7	28.5	6.5	46.7	30.3	22.8	16.3
Monocacy River Upper	60.2	36.6	3.3	50.7	39.7	9.5	6.2
Nanjemoy Creek	15.6	71.9	3.2	14.7	69.4	6.7	3.5
Nanticoke River	31.8	38.5	1.5	31.3	36.8	4.6	3.1
Nassawango Creek	26.3	72.8	0.4	25.1	70.8	3.6	3.2
Northeast River	39.0	43.5	8.1	33.3	39.6	17.6	9.5
Octoraro Creek	62.0	33.6	4.4	50.6	30.8	18.4	14.0
Patapsco River Lower North Branch	17.3	51.1	30.0	12.2	38.6	47.0	17.0
Patuxent River Lower	24.7	53.6	6.0	20.4	44.4	19.3	13.3
Patuxent River Middle	42.0	48.2	3.5	36.9	43.2	13.9	10.4
Patuxent River Upper	25.9	52.3	21.4	18.1	44.4	35.6	14.2
Piscataway Creek	18.1	55.8	23.6	14.2	43.0	39.5	15.9

Table 9-6. (Continued)

Watershed	1973 (%) Agriculture	1973 (%) Forest	1973 (%) Urban	2000 (%) Agriculture	2000 (%) Forest	2000 (%) Urban	% Change Urban
Pocomoke River Lower	35.1	57.9	3.0	33.7	57.4	4.6	1.6
Pocomoke River Upper	44.2	55.2	0.7	43.6	52.3	4.0	3.3
Pocomoke Sound	20.7	32.7	0.3	19.4	31.3	3.6	3.3
Port Tobacco River	21.6	61.7	9.4	19.0	52.6	20.6	11.2
Potomac River Lower North Branch	14.0	75.8	8.7	11.4	73.8	13.6	4.9
Potomac River Upper North Branch	17.6	75.3	6.0	15.2	74.1	9.6	3.6
Potomac River Washington County	42.0	47.7	2.6	33.8	46.5	12.5	9.9
Potomac River Frederick County	56.0	34.3	4.3	42.2	36.8	15.9	11.6
Potomac River Montgomery County	40.6	32.2	20.6	25.7	29.0	37.3	16.7
Potomac River Lower Tidal	7.6	12.3	1.3	7.1	11.6	2.7	1.4
Potomac River Middle Tidal	3.6	35.8	2.9	3.2	34.1	5.1	2.2
Potomac River Upper Tidal	7.0	39.2	29.8	4.4	26.6	41.9	12.1
Prettyboy Reservoir	54.2	37.6	5.0	45.8	36.8	14.1	9.1
Rocky Gorge Dam	48.3	36.5	12.0	27.9	38.0	31.0	19.0
Savage River	14.9	82.8	1.2	14.4	81.4	3.4	2.2
Seneca Creek	57.5	32.2	9.7	34.4	32.6	32.0	22.3
Sideling Hill Creek	20.0	80.1	0.0	17.6	79.0	3.2	3.2
St. Clements Bay	37.2	48.7	3.1	34.6	45.7	8.5	5.4
St. Mary's River	20.7	55.3	6.4	18.0	47.6	16.1	9.7
Susquehanna River Lower	27.6	39.0	15.9	23.0	33.9	24.1	8.2
Susquehanna River Conowingo Dam	33.3	49.3	3.4	30.0	35.8	11.7	8.3
Swan Creek	40.9	36.9	17.5	31.7	32.5	30.7	13.2
Town Creek	18.7	80.9	0.4	19.3	78.4	2.3	1.9
Transquaking River	42.7	37.9	0.3	43.9	35.1	1.7	1.4
Tuckahoe Creek	69.1	28.6	0.6	68.5	26.2	3.6	3.0
Western Branch	33.1	48.9	17.4	15.0	39.3	42.5	25.1
Wicomico Creek	39.0	53.8	1.5	38.5	50.9	10.4	8.9
Wicomico River Head	43.8	46.0	9.8	35.1	38.7	25.3	15.5
Wills Creek	11.7	74.5	13.7	9.0	73.4	17.5	3.8
Wye River	63.5	23.6	1.1	59.4	21.6	6.8	5.7
Youghiogheny River	29.4	68.7	1.1	25.6	65.8	7.5	6.4
Zekiah Swamp	26.5	67.5	5.6	22.1	58.0	18.1	12.5

9.5.2 Distribution and Relative Abundance

A total of 416 benthic macroinvertebrate genera in 113 families were represented in the MBSS dataset. (Appendix C.) Most of the genera identified were rare. Three hundred twenty-three genera (78%) occurred at less than 5% of all sites and 221 genera (53%) were even more rare, occurring at less than 1% of all sites. There were 59 genera collected at only one site, while only 14 genera occurred at more than 25% of all sites.

The statewide frequencies of occurrence (percentage of sites) for each family and genus of the most commonly occurring orders of insects (Diptera, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, and Odonata) were calculated and graphed (Figures 9-21 to 9-28) to illustrate their distribution in the MBSS dataset. Some of the most frequently collected families were non-biting midges (Diptera: Chironomidae) (97% of all sites sampled), hydropsychid caddisflies (Trichoptera: Hydropsychidae) (61%), ephemerellid mayflies (Ephemeroptera: Ephemerellidae) (51%), and nemourid stoneflies (Plecoptera: Nemouridae) (48%). Widely distributed genera, like *Cheumatopsyche, Hydropsyche, Ephemerella,* and *Amphinemura* were largely responsible for the above-mentioned patterns. It is important to consider scale when reviewing these graphs; taxa that were common within a limited geographic area could not be distinguished from others that had a widespread distribution but were uncommon in collections. The mayfly *Caenis,* for example, was relatively rare statewide (4%), but was collected at 45% of sites in the Elk River watershed (Appendix C).

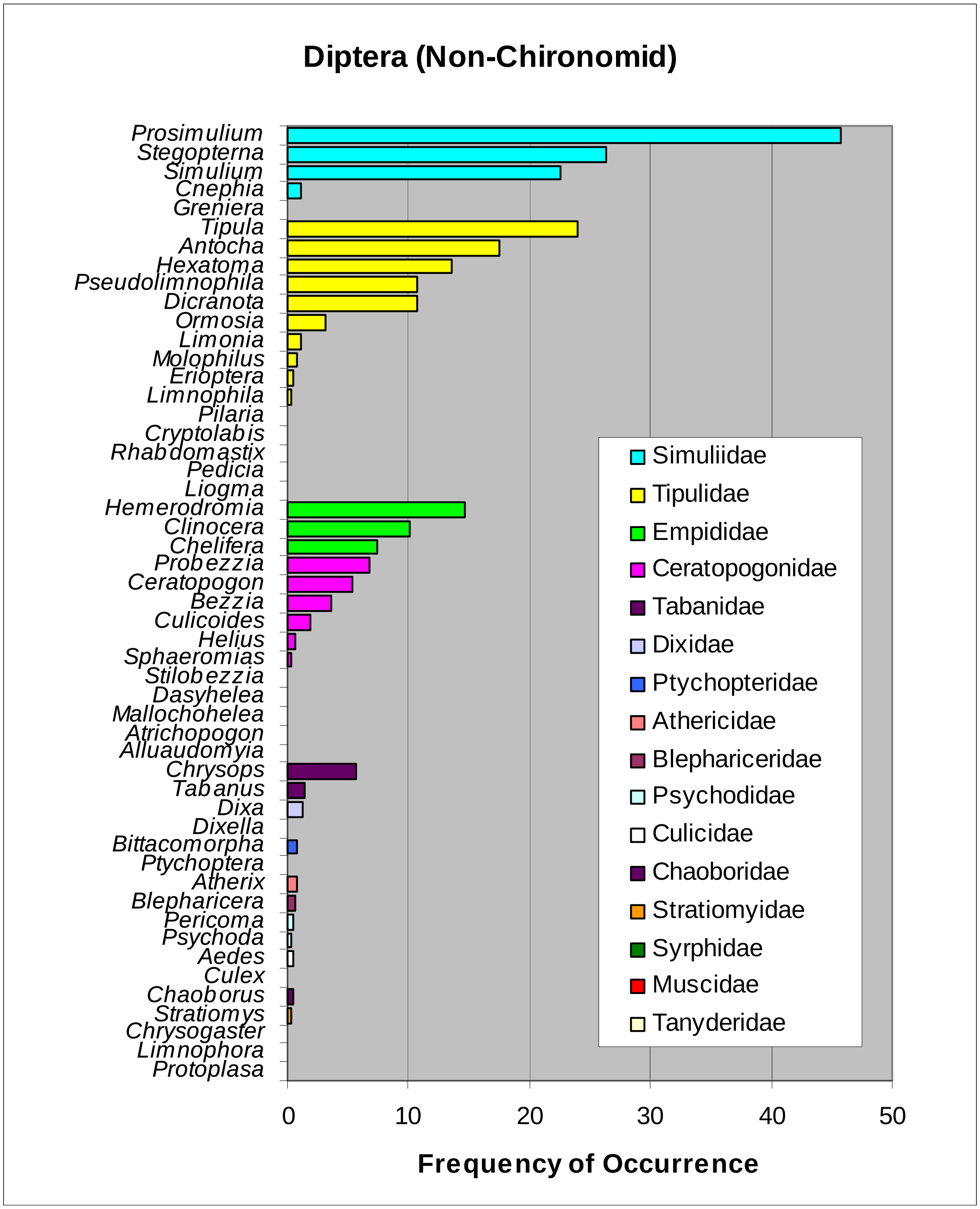


Figure 9-21. Statewide frequency of occurrence (percentage of sites) for Diptera taxa based on 1994-2004 MBSS benthic data

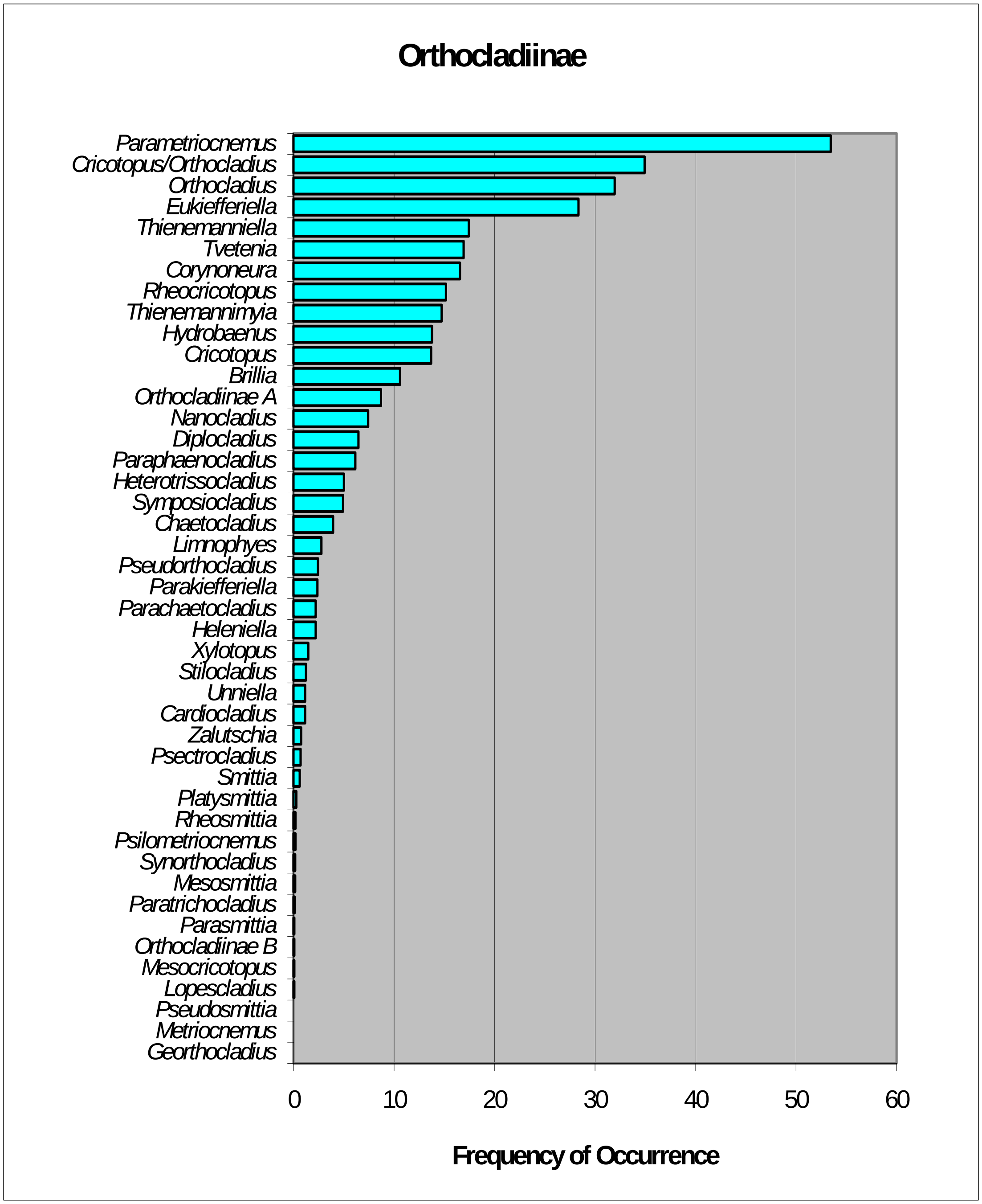


Figure 9-22. Statewide frequency of occurrence (percentage of sites) for Orthocladiinae (Diptera: Chironomidae) taxa based on 1994-2004 MBSS benthic data

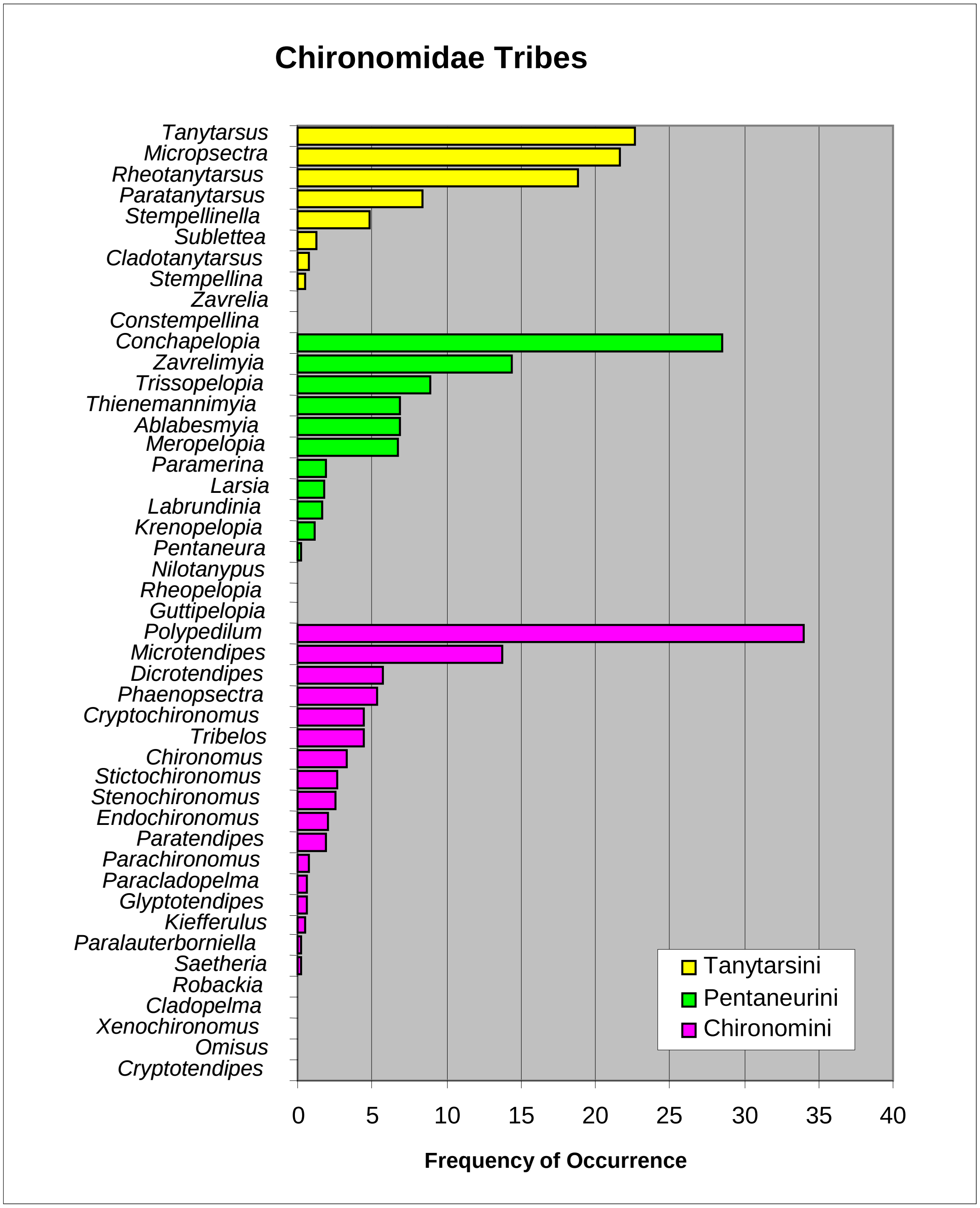


Figure 9-23. Statewide frequency of occurrence (percentage of sites) for Chironomidae taxa based on 1994-2004 MBSS benthic data

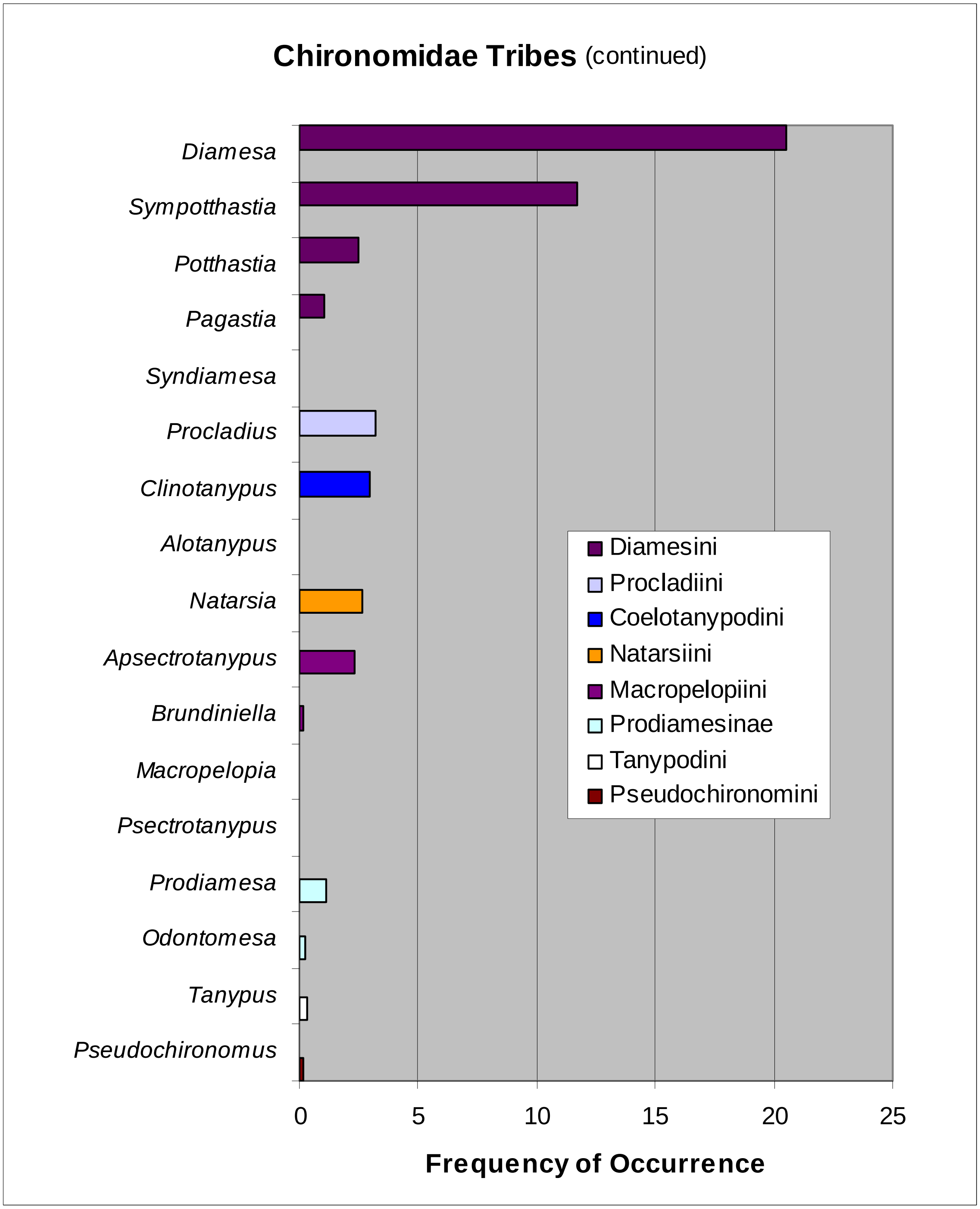


Figure 9-23. (Continued)

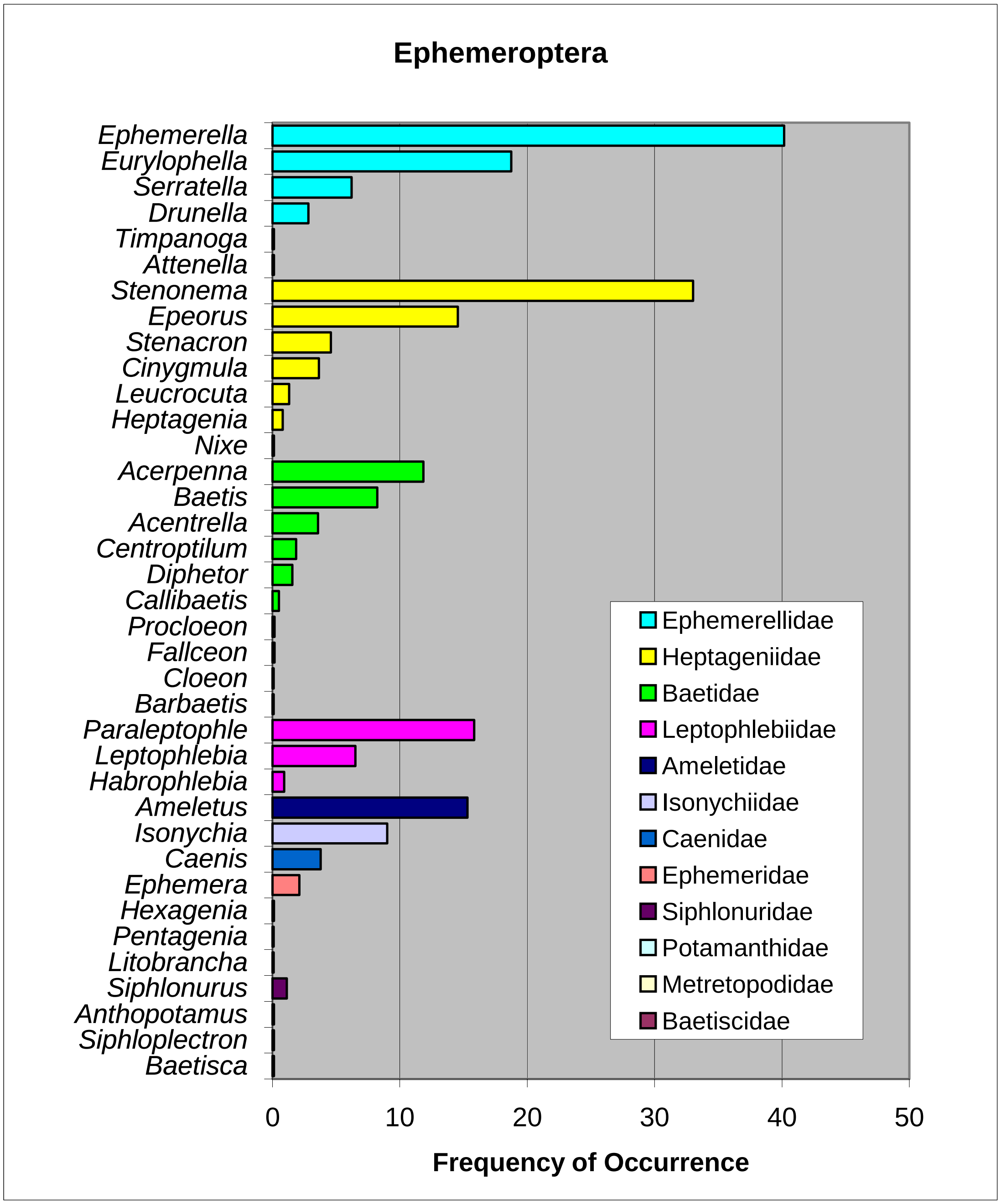


Figure 9-24. Statewide frequency of occurrence (percentage of sites) for Ephemeroptera taxa based on 1994-2004 MBSS benthic data

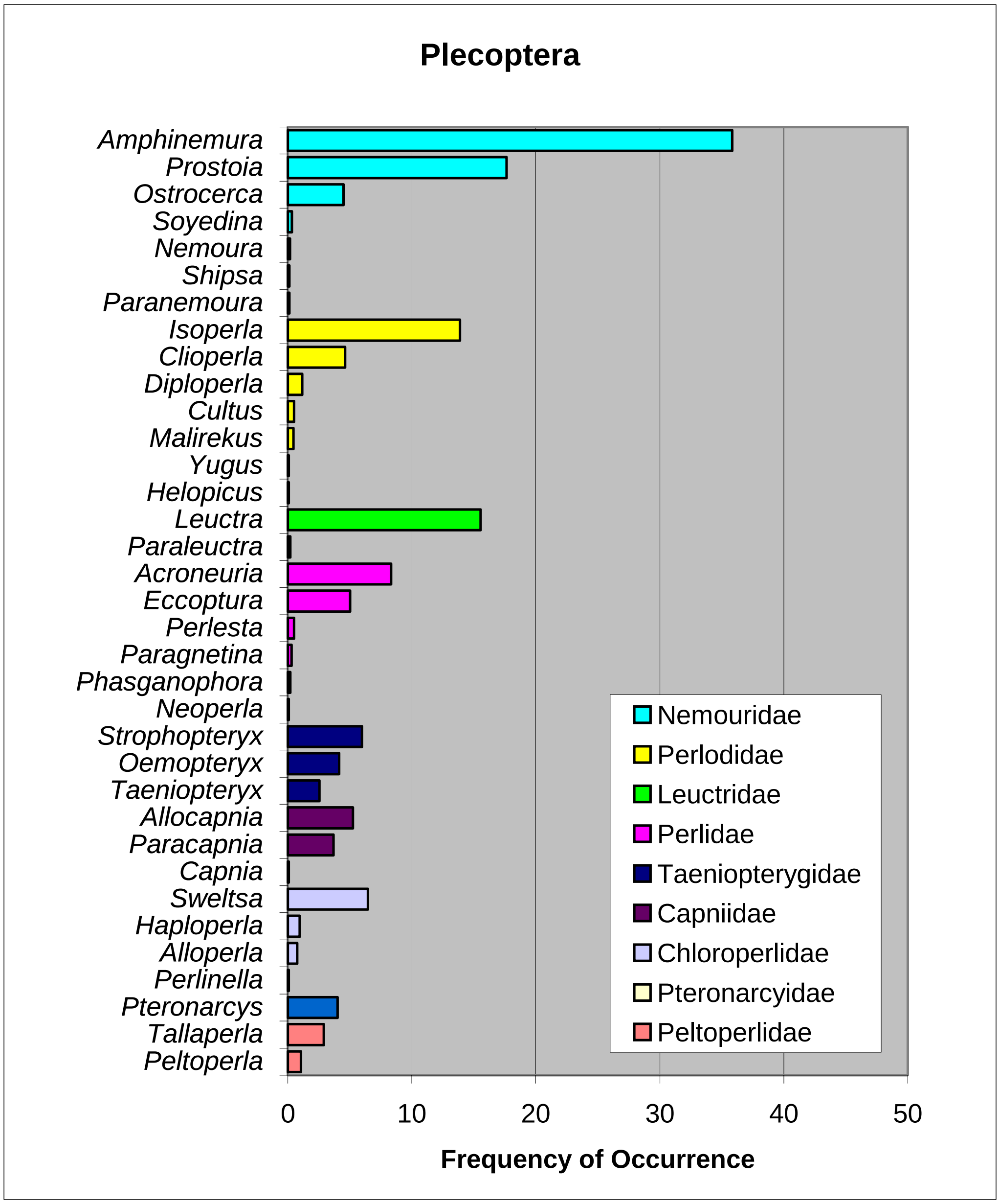


Figure 9-25. Statewide frequency of occurrence (percentage of sites) for Plecoptera taxa based on 1994-2004 MBSS benthic data

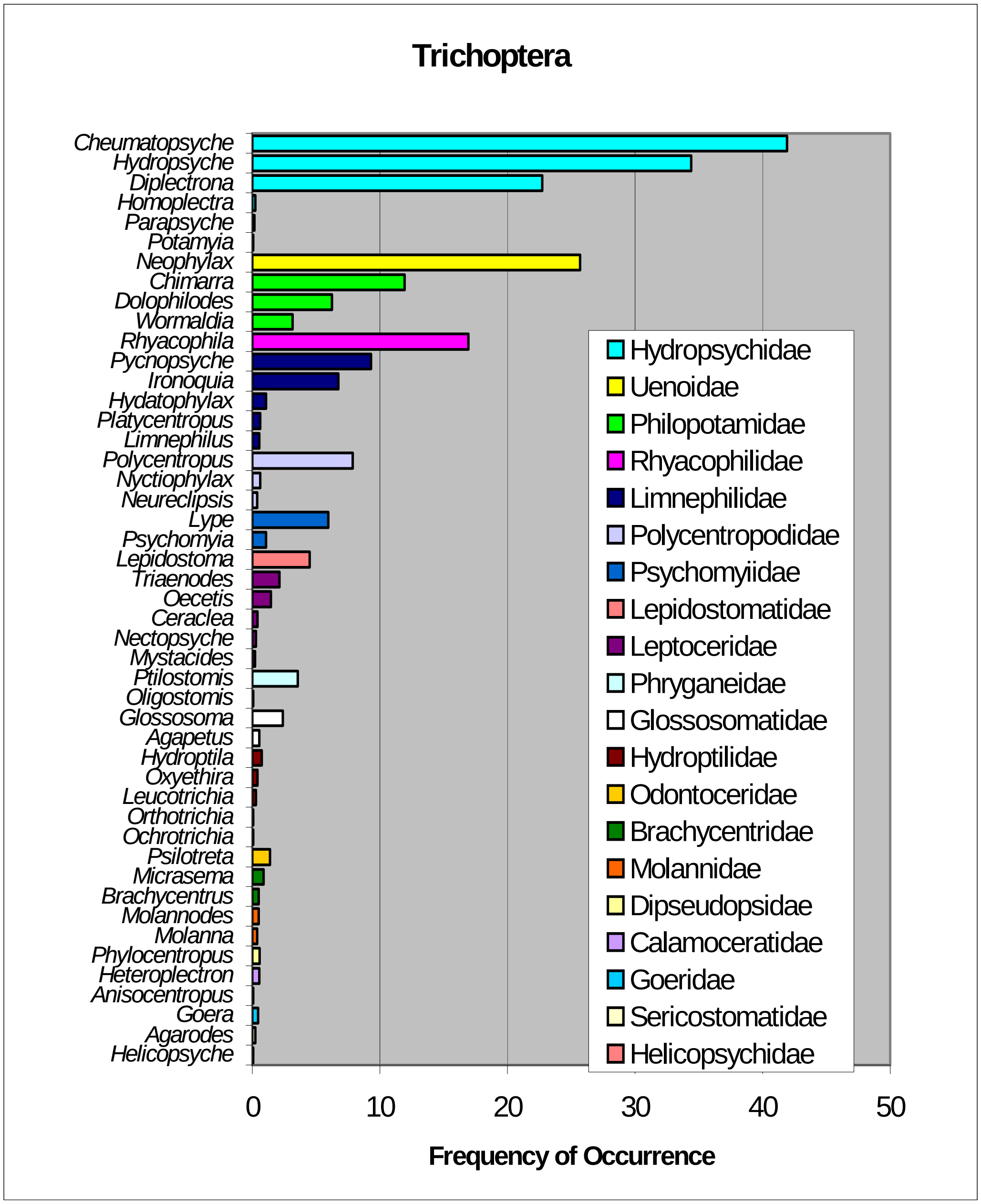


Figure 9-26. Statewide frequency of occurrence (percentage of sites) for Trichoptera taxa based on 1994-2004 MBSS benthic data

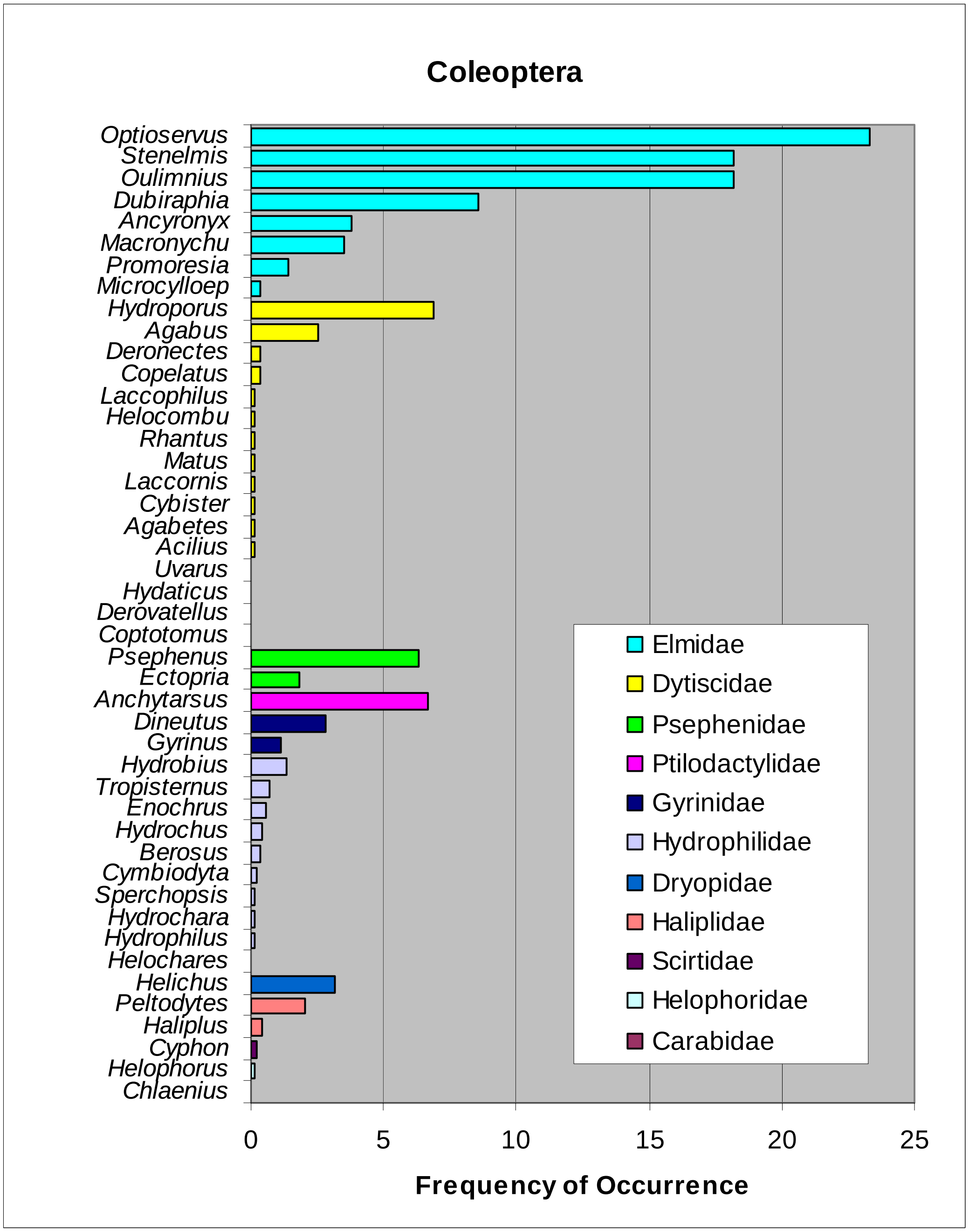


Figure 9-27. Statewide frequency of occurrence (percentage of sites) for Coleoptera taxa based on 1994-2004 MBSS benthic data

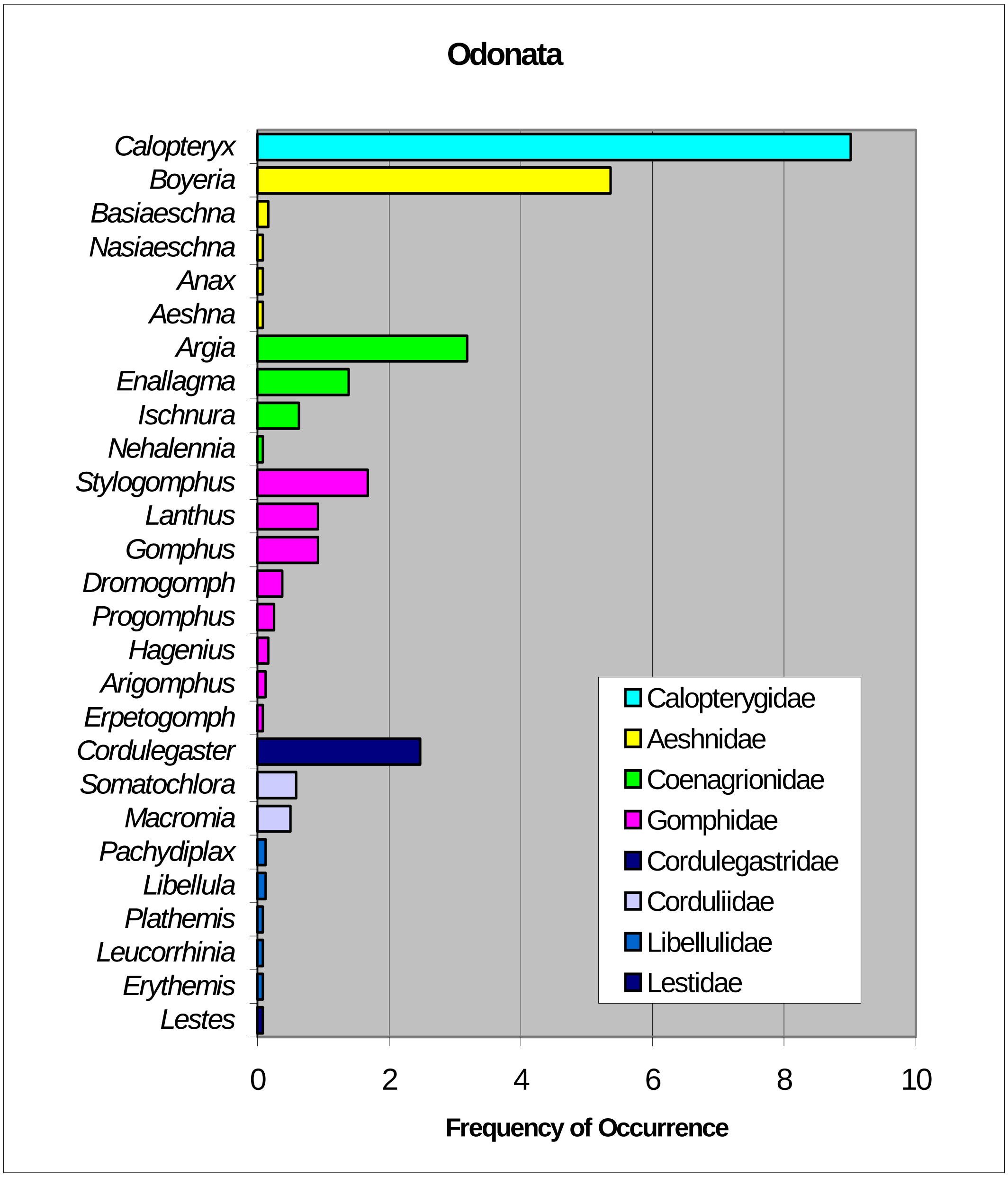


Figure 9-28. Statewide frequency of occurrence (percentage of sites) for Odonata taxa based on 1994-2004 MBSS benthic data

9.5.3 Descriptions of Major Invertebrate Taxa

9.5.3.1 Diptera

Dipterans represent nearly half (48%) of the invertebrate individuals found in MBSS benthic macroinvertebrate sub-samples. In terms of absolute numbers, 101,000 dipterans in 17 families (154 genera) were collected. Diversity of dipterans genera was generally high in many of the watersheds sampled (Figure 9-29). Fifty-eight (58%) of the watersheds sampled contained more than 50 genera of dipterans. Only the Georges Creek watershed contained fewer than thirty dipteran genera.

Freshwater Invertebrates were also classified according to their functional feeding group (FFG) (Merritt and Cummins, 1996). Functional feeding group designations classify organisms according to their role in processing organic matter. Dipterans were separated into five primary FFGs: collectors, filters, predators, scrapers, and shredders. Collectors (43%) and filterers (33%) accounted for three quarters of the total taxa count.

The dipteran family Chironomidae is one of the most diverse but poorly understood families of all benthic macroinvertebrates. A total of 111 genera of chironomids were identified in MBSS samples. Orthocladinae midges were by far the most commonly encountered subfamily (95% of all sites), with 42 genera. *Parametriocnemus*, *Cricotopus,* and *Orthocladius* were dominant genera (Figure 9-22). Genera within the tribe Tanytarsini (subfamily Chironominae) were second at 61% (only 10 genera), with *Tanytarsus* and *Microspecra* the most frequently encountered taxa (about 21% each) (Figure 9-23**).** *Tanypus* (subfamily Tanypodinae) and *Pseudochironomus* (tribe Psuedochironomini) represented the only tribes and subfamilies of midges found at less than 1% of MBSS sites, respectively**.** These genera were, however, the sole representatives of their tribe or subfamily in the dataset. Forty-one other genera of Chironomidae were found at less than 1% of MBSS sites, with 9 genera identified at only one site. Black flies (Simuliidae) and crane flies (Tipulidae) were the second and third most abundant families of dipterans collected, comprising together about 15% of the total number of all individuals. No aquatic dipterans are identified as rare or in need of conservation in the Maryland DNR 2003 list of Rare, Threatened, and Endangered Animals of Maryland.

9.5.3.2 Ephemeroptera

A total of 37 genera of mayflies in 12 families comprised 17% of the individual organisms in MBSS samples. Several genera, such as *Ephemerella* and *Stenonema*, were commonly encountered and had widespread geographic distributions (Figures 9-24 and 9-30). Generally, ephemeropteran taxa richness decreased with decreasing gradient, elevation, and abundance of rocky stream substrates.

Watersheds in western Maryland, such as the Youghiogheny, Casselman, and Savage, generally contained communities rich in Ephemeroptera taxa (> 16)**.** Conversely, streams in the lower Coastal Plain (Nanticoke/Wicomico, Pocomoke, and Ocean Coastal basins) had relatively few Ephemeroptera taxa. The majority of ephemeropterans (75% of individuals and 70% of genera) identified were classified as collectors. *Siphloplectron* was the only genus of this order collected (from the Lower Potomac) that was classified as a predator.

Genera from the families Potamanthidae, Metretopodidae, and Baestiscidae were infrequently encountered in collections, but the genera *Timpanoga, Atenella,* and *Barbaetis,* of the more common families Ephemerellidae and Baetidae were also found to be rare relative to other benthic macroinvertebrates. The Rare, Threatened and Endangered Animals of Maryland list includes one species of mayfly (*Potamanthus walkeri*) as 'Possibly rare' and two others (*Paraleptophlebia assimilis* & *Tricorythodes robacki*) as 'under review for inclusion on list.'

9.5.3.3 Plecoptera

Thirty-five genera in nine families of stoneflies were found in MBSS samples. Common and widely distributed genera included *Amphinemura*, *Isoperla,* and *Leuctra* (Figure 9-25). Several watersheds in western (Youghiogheny, Savage) and central Maryland (upper and lower Monocacy, Deer Creek) were rich in Plecoptera genera, as were some watersheds on the lower Western shore (Patuxent River lower, Mattawoman Creek) (Figure 9-31). Conversely, streams on the lower eastern shore (Nanticoke/Wicomico, Pocomoke, and Ocean Coastal basins) generally contained fewer plecopteran genera.

Although the number of stonefly genera was evenly split between the FFG classifications of predators and shredders, 83% of the plecopteran individuals collected during the 1994-2004 MBSS were classified as shredders.

The stoneflies *Helopicus* and *Yugus* (Perlodidae), *Perlinella* (Chloroperlidae), and *Capnia* (Capniidae) were infrequently collected in MBSS samples. Concentrated surveys of Plecoptera were conducted from 1984-1990 in Allegany, Frederick, Garrett, and Washington counties (Grubbs, 1999). In this study, 103 species from 43 genera were identified. Fourteen species were identified as rare or uncommon, or species with Maryland as the terminal region for their distribution. One plecopteran, *Allocapnia wrayi*, is under review for inclusion on the list of Rare, Threatened and Endangered Animals of Maryland as 'Possibly Rare.'

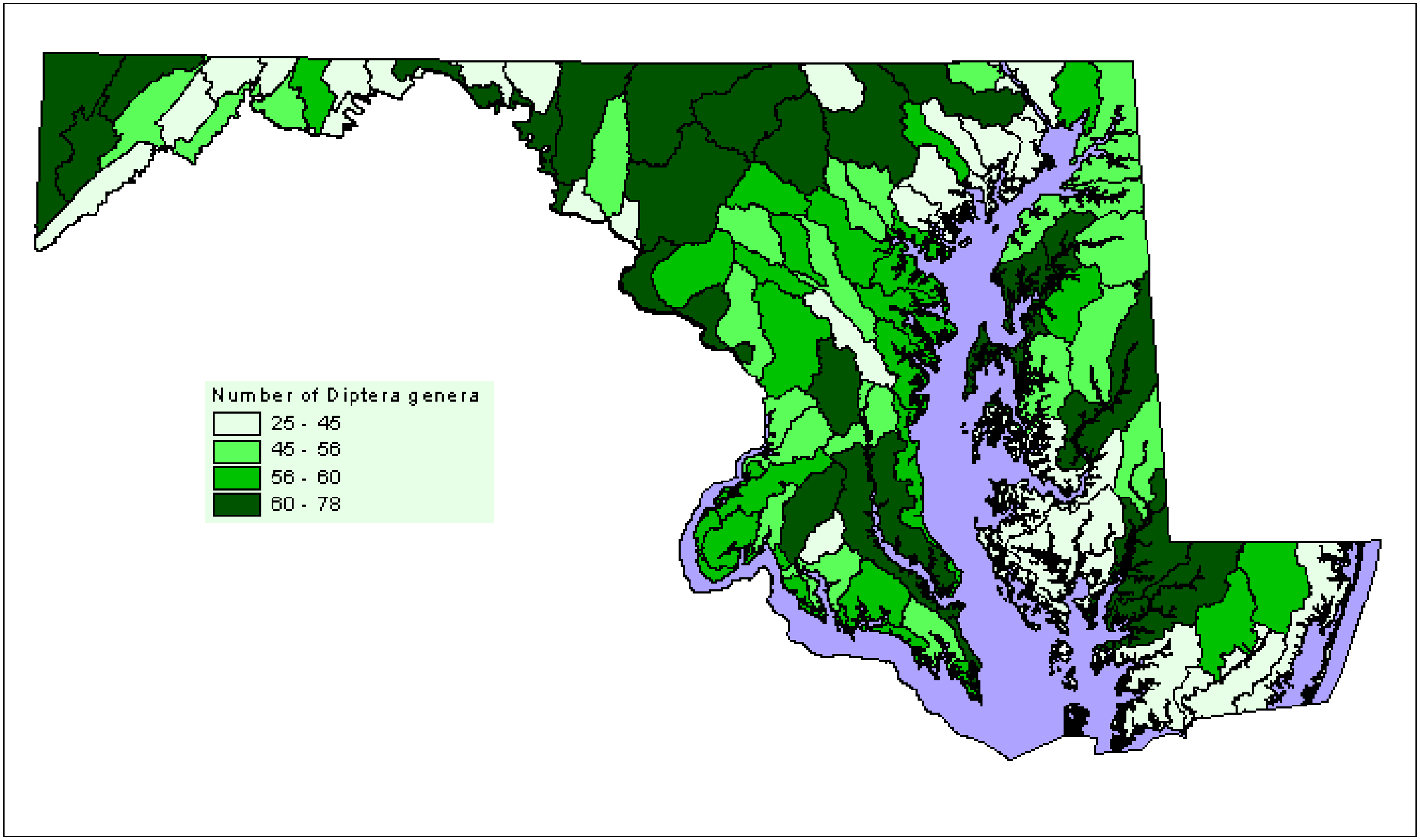


Figure 9-29. Statewide richness map of Diptera genera by watershed, based on 1994-2004 MBSS benthic data

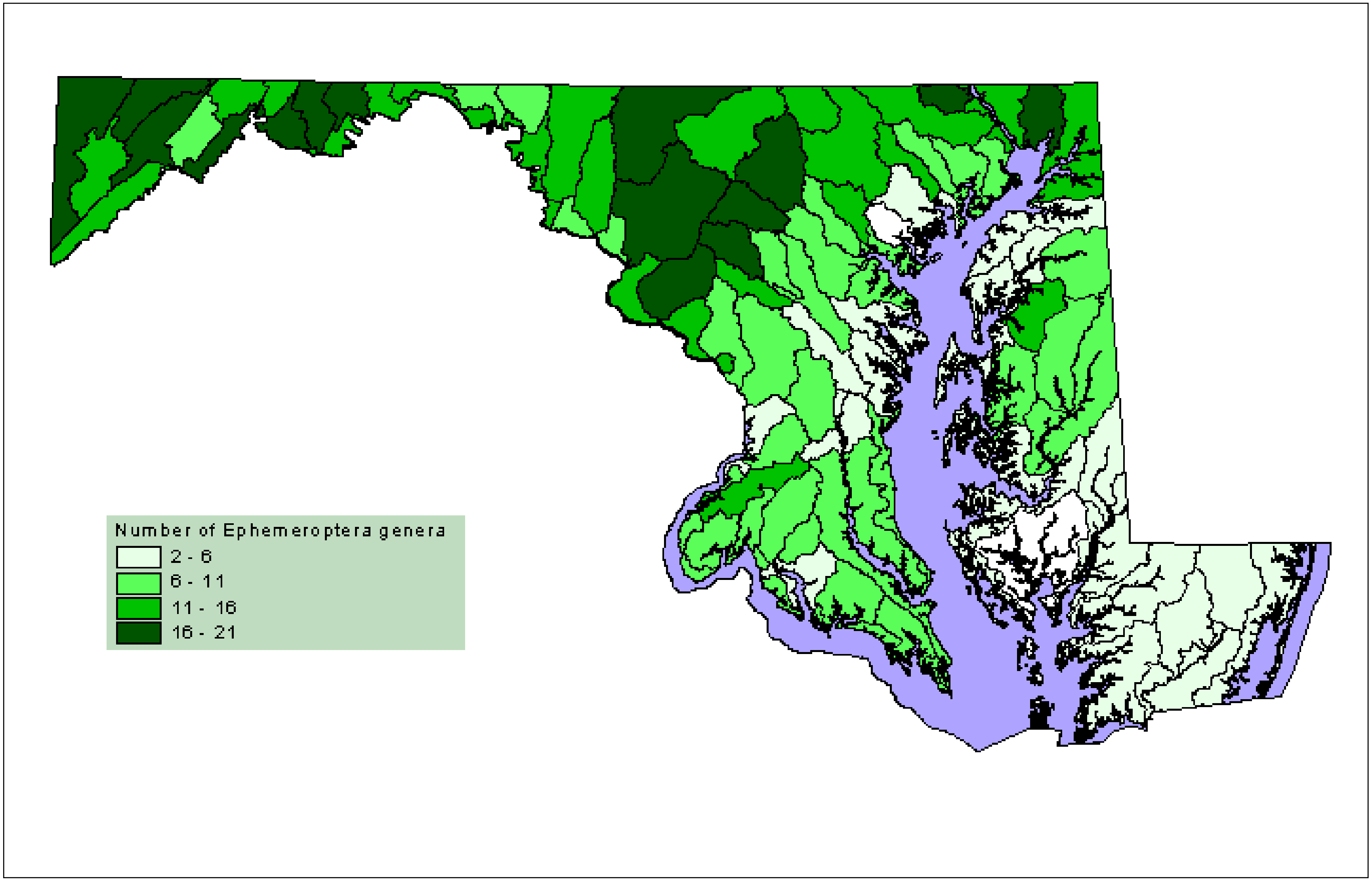


Figure 9-30. Statewide richness map of Ephemeroptera genera by watershed based on 1994-2004 MBSS benthic data

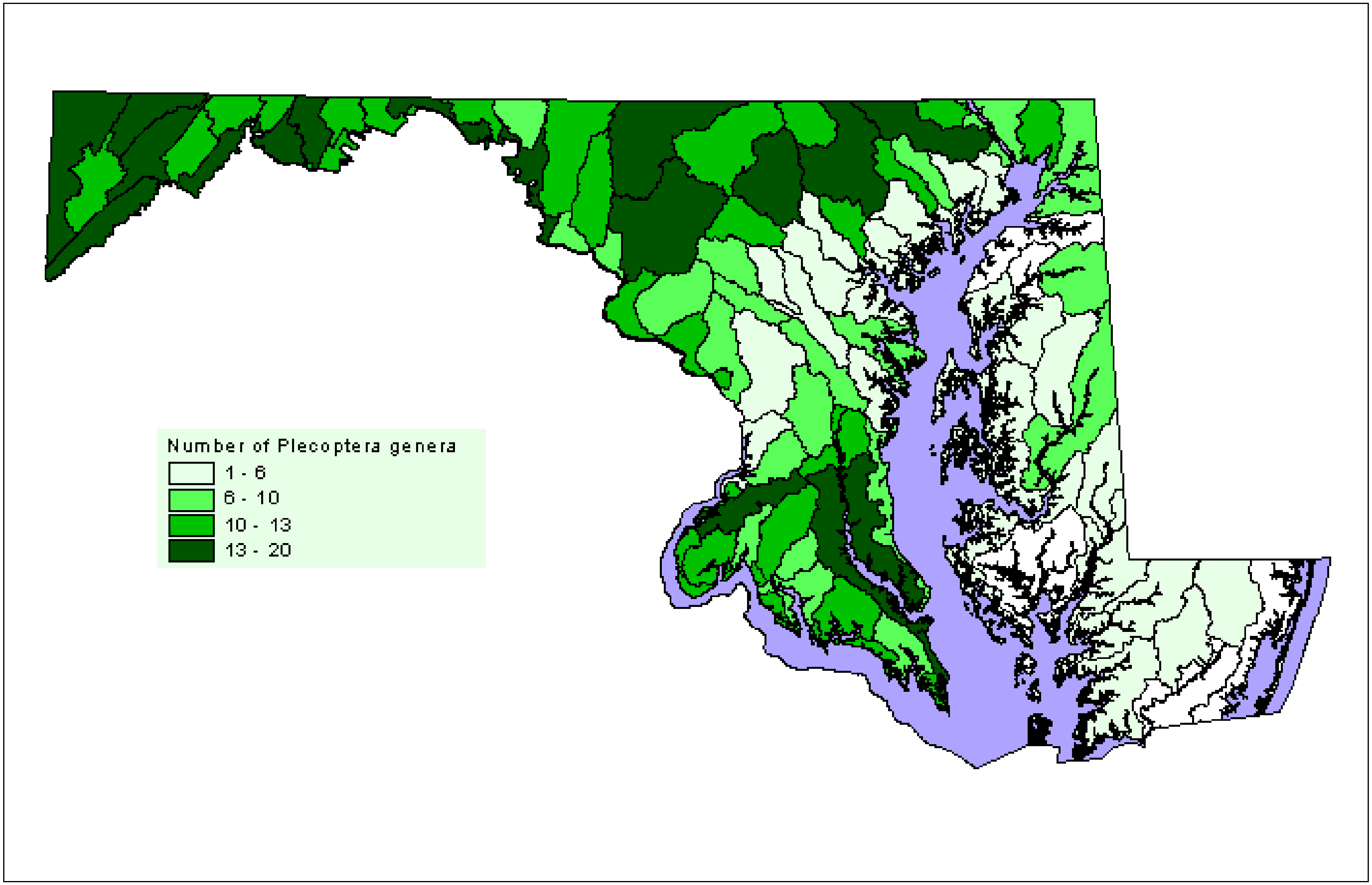


Figure 9-31. Statewide richness map of Plecoptera genera by watershed based on 1994-2004 MBSS benthic data

9.5.3.4 Trichoptera

Forty-seven genera in 20 families of caddisflies were collected in 1994-2004 MBSS samples. Two genera of hydropsychid caddisflies, *Hydropsyche* and *Cheumatopsyche*, were widely distributed and frequently collected (Figure 9-26). These genera are commonly considered to be tolerant of pollution and are often found in streams within highly urbanized watersheds. Along with four other genera in the family Hydropsychidae, these taxa were largely responsible for the high proportion (74%) of filtering organisms in the Trichoptera. The Deer Creek and Zekiah Swamp watersheds contained the largest number of caddisfly genera (23), but several watersheds in western Maryland were also found to be diverse (Figure 9-32).

Three genera (*Ochrotrichia*, *Anisocentropus*, and *Oligostomis*) were represented by single organisms from only one collection. One species of Trichoptera, *Hydropsyche brunneipennis,* is listed as (S3) 'Watch list' (DNR, 2003b).

9.5.3.5 Coleoptera

A total of 44 genera of aquatic beetles from 10 families comprised 4.5% of the organisms in MBSS samples. The elmids (riffle beetles), *Optioservus*, *Stenelmis*, and *Olimnius,* were by far the most commonly encountered coleopteran genera (Figure 9-27). One-fourth of the coleopteran were primarily responsible for the disproportionately large percentage (84%) of scrapers in the Coleoptera. Riffle beetles, water penny beetles (Psephenidae), and marsh beetles of the genus *Cyphon* (Scirtidae) were largely responsible for this discrepancy. The Dytiscidae (predaceous diving beetles) contained the highest number (16) of coleopteran genera and made up the bulk of the predators collected in this order (6.4% of all coleopterans). The majority of dytiscid genera were infrequently collected. *Uvarus, Hydaticus, Derovatellus*, and *Coptotomus* were collected at only one site. Coleopteran diversity was fairly evenly distributed across the State (Figure 9-33).

Six genera of aquatic beetles were listed at various threat levels, and four others are identified as 'under review for inclusion on list' of Rare, Threatened, and Endangered Animals of Maryland (DNR, 2003).

9.5.3.6 Odonata

Twenty-seven genera in eight families of dragonflies and damselflies were collected in MBSS samples. *Calopteryx,* a broad-winged damselfly, and *Boyeria*, a darner (Aeshnidae), were the most frequently collected odonates (Figure 9-28). Odonate richness was generally higher in Maryland's coastal plain, with the Upper Chester and Upper Pocomoke river basins containing the most genera (Figure 9-34). Nine genera were represented by single collections. A total of 110 species of Odonata are listed in the Rare, Threatened and Endangered Animals of Maryland (DNR, 2003b). Twenty-four are listed as S1 (Highly State Rare) and twenty-three as S2 (State Rare).

9.5.3.7 Crayfishes

Because historic data on the distribution of native and non-native crayfish exists for Maryland, and the MBSS collected and identified crayfishes to species during 1996-97, this chapter contains an expanded section describing Maryland crayfish fauna.

Eleven species of crayfishes are known to occur in Maryland (Meredith and Schwartz 1960; McGregor 1999; DNR unpublished Natural Heritage Program data), and nine species are considered native. Of these nine, five species are most often associated with stream habitats. These include *Cambarus acuminatus*, *C. bartonii*, *Procambarus acutus*, *Orconectes obscurus*, and *O. limosus*. The four remaining natives, *C. dubius C. monongalensis*, *C. diogenes*, and *Fallicambarus fodiens* are primarily burrowing species generally associated with wetlands and floodplains. Non-native species reported from Maryland include *O. virilis* and *Procambarus clarkii*. Although likely introduced, there are no confirmed records of *O. rusticus* in Maryland. Two additional species, *C. carinirostrus*, and *C. robustus*, are known from portions of the Potomac basin in West Virginia, and may be present in tributaries to the Potomac River in Garrett County. However, their presence has yet to be confirmed in Maryland (Loughman 2004, personal communication).

As part of the 1996-1997 Maryland Biological Stream Survey, crayfishes were collected during electrofishing at 619 of 650 randomly selected sites in 13 major river basins in the State. Seven stream crayfish species (six native and one non-native species) were collected by the MBSS. The focus of the MBSS on lotic habitats was probably responsible for the absence of *C. dubius*, *C. monongalensis*, and *F. fodiens* from collections. These three primarily burrowing species are only occasional (usually seasonal and nocturnal) occupants of stream habitats. The Upper Potomac, Lower Potomac, Chester, Nanticoke/Wicomico, and Ocean Coastal basins were not sampled by MBSS during this period. The spatial coverage of MBSS (1996-1997) was not sufficient to capture *P. clarkii,* a species known only from the Nanticoke/Wicomico basin in Maryland (Figure 9-35).

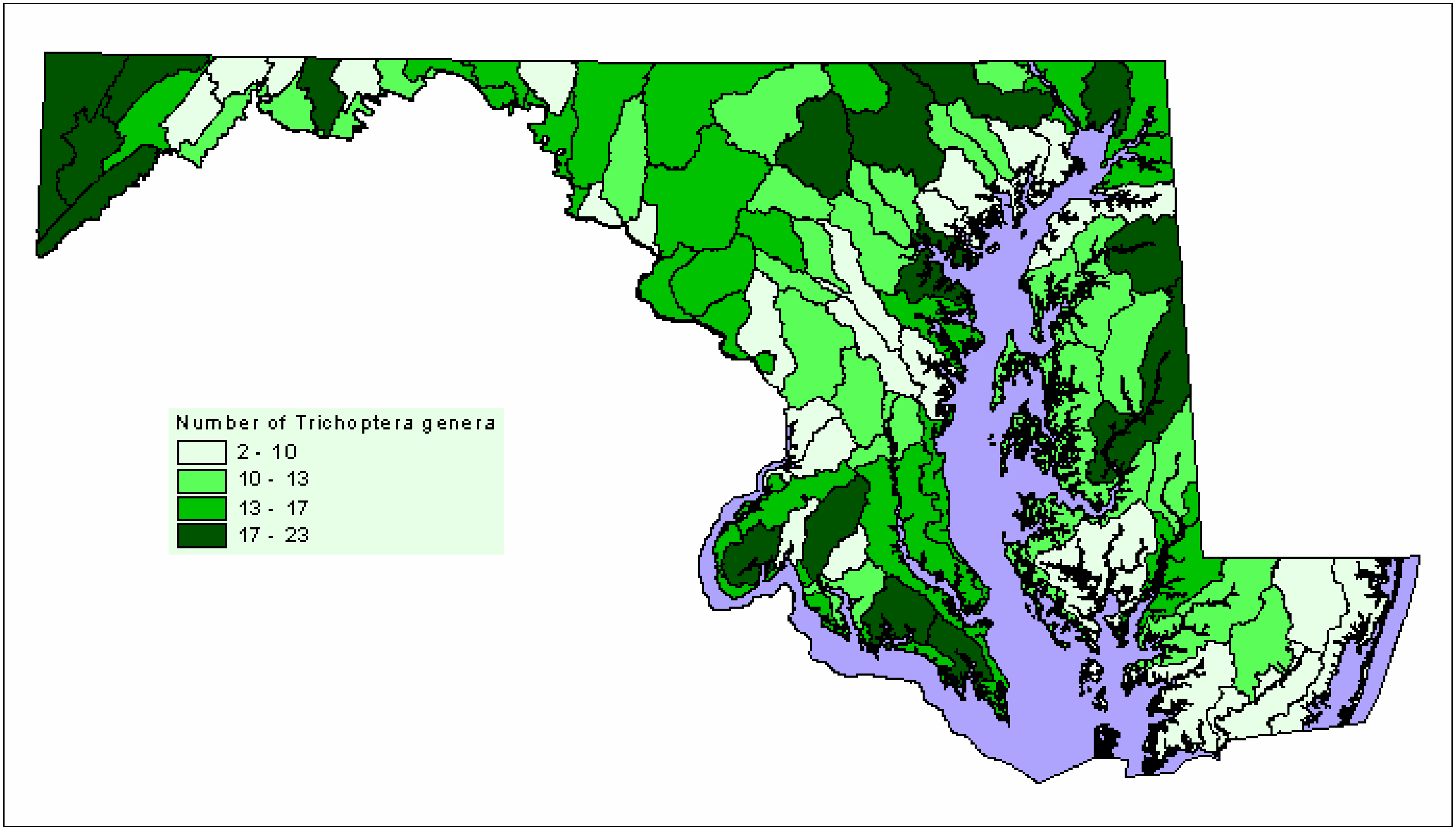


Figure 9-32. Statewide richness map of Trichoptera genera by watershed based on 1994-2004 MBSS benthic data

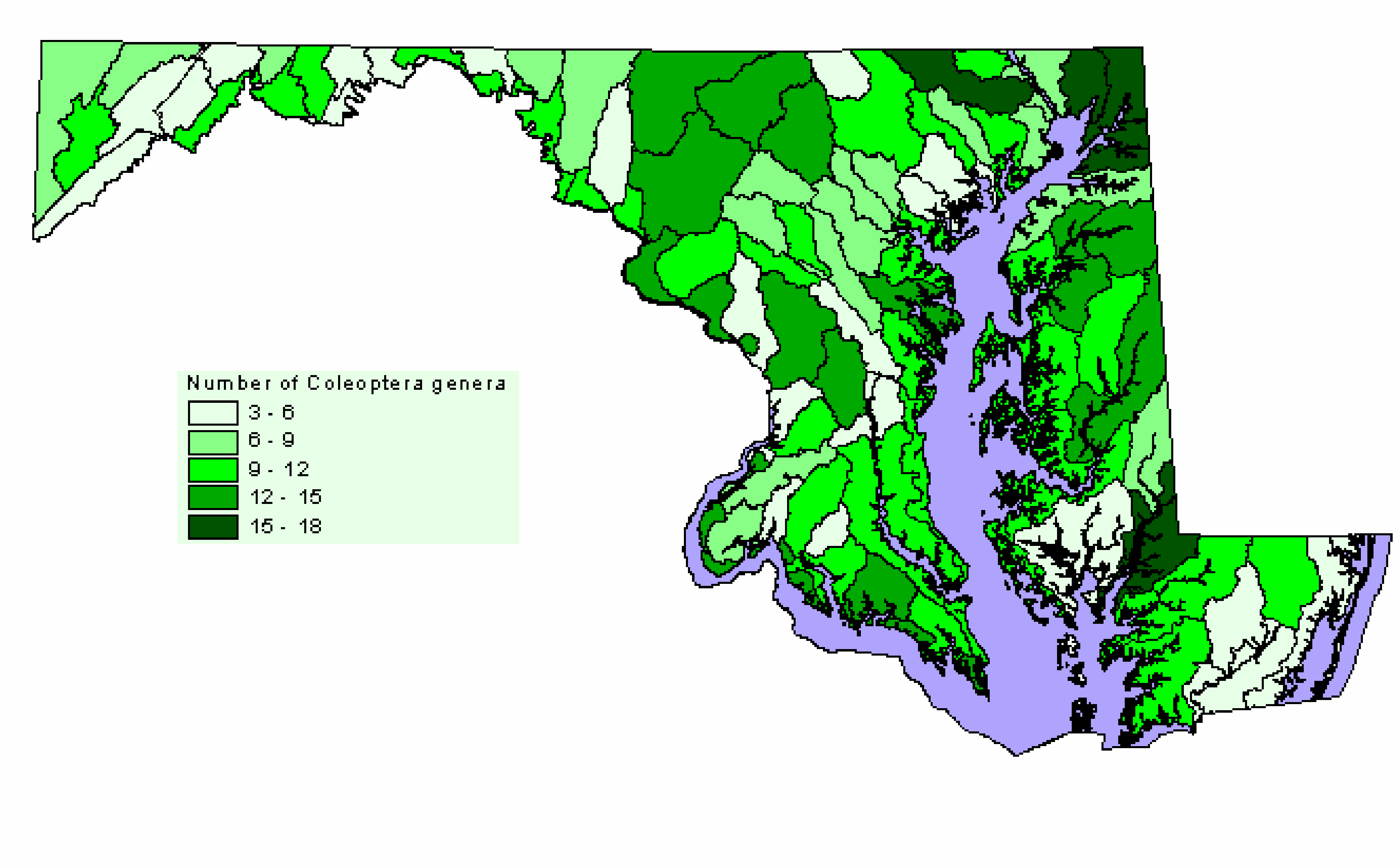


Figure 9-33. Statewide richness map of Coleoptera genera by watershed based on 1994-2004 MBSS benthic data

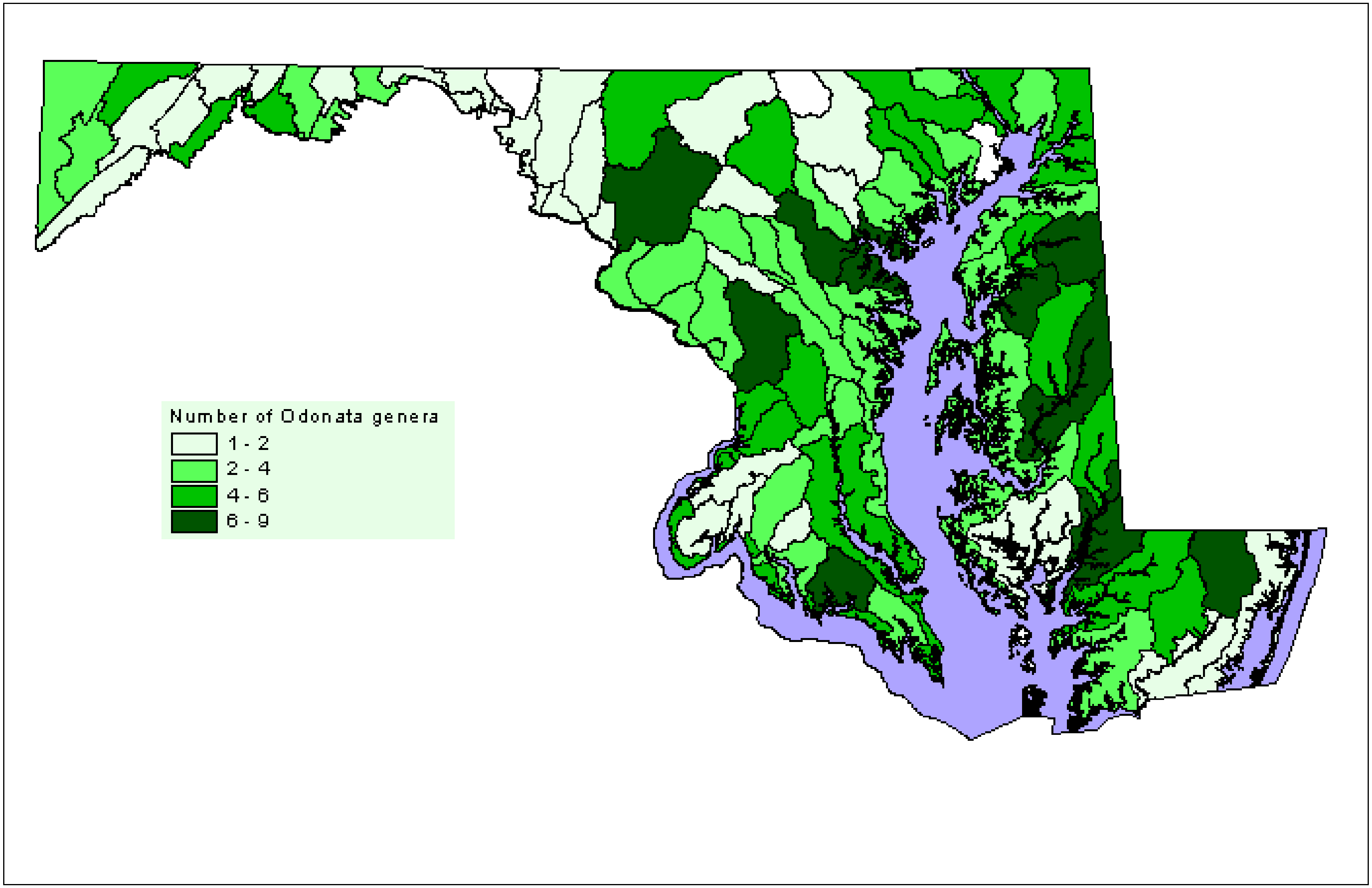


Figure 9-34. Statewide richness map of Odonata genera by watershed based on 1994-2004 MBSS benthic data

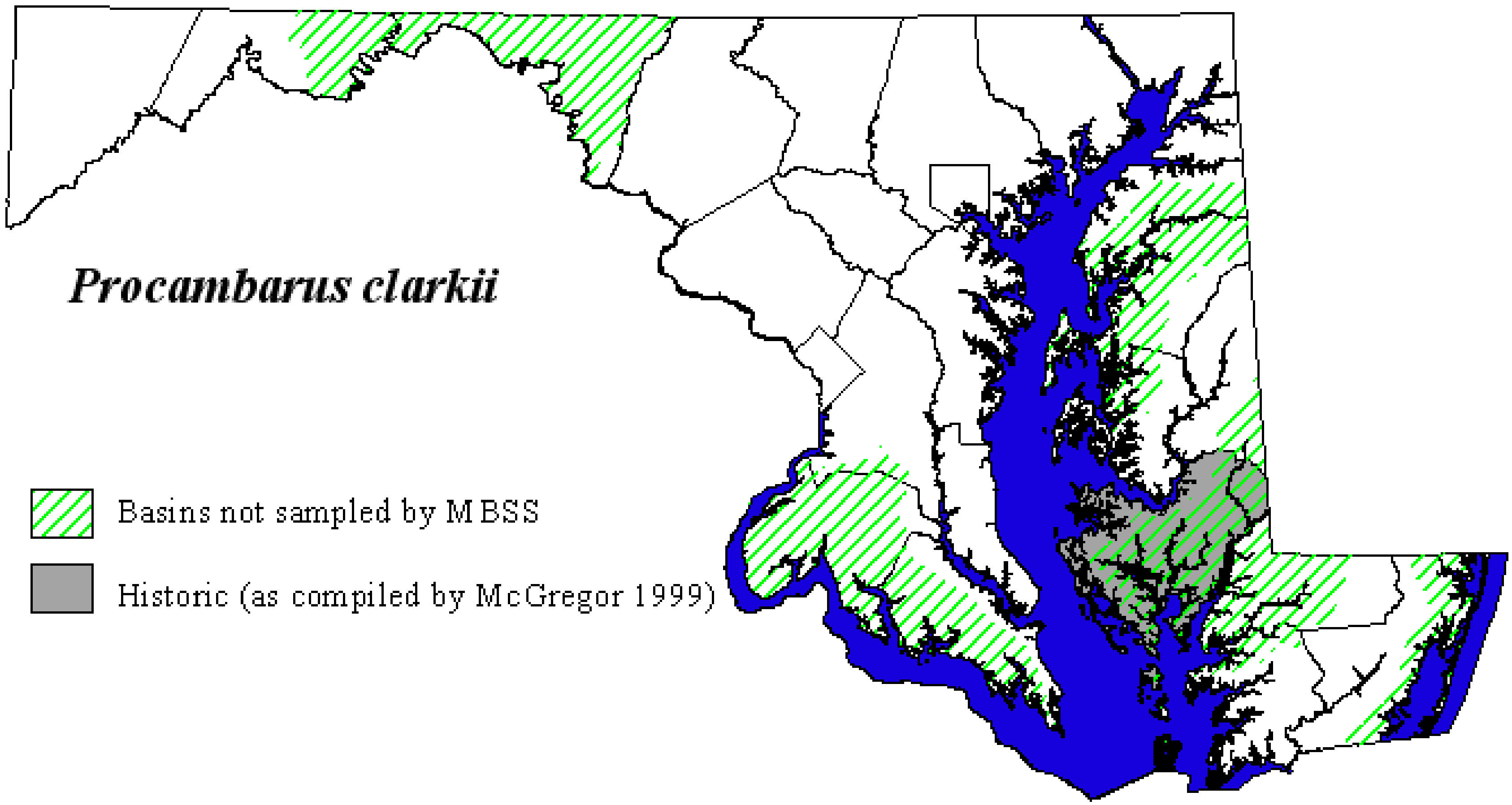


Figure 9-35. Historic and current distribution (no specimens were collected in the 1996-1997 MBSS) of the non-native crayfish *Procambarus clarkii* in Maryland based on historic distribution reported in McGregor 1999 and the 1996-1997 MBSS. None were collected in the 1996-1997 MBSS.

Maps of five stream species collected by the MBSS depict historic (as compiled by McGregor 1999) and present (MBSS 1996-1997) distributions of these species in Maryland (Figures 9-36 to 9-40). MBSS collections of *O. obscurus* in Allegany, Cecil, and Montgomery counties represent the first known records of this species at these locations (Figure 9-36). MBSS crayfish records provide evidence of apparent reductions in the distributions of *C. bartonii* and *O. limosus*, two of the (historically) more common and abundant stream species in Maryland (Meredith and Schwartz 1960), with concomitant expansion of introduced *O. virilis* (see Section 9.8.3).

9.5.3.8 Bivalves

Seven genera of bivalves were observed during MBSS sampling from 1995-2004. These included two genera of fingernail clams (Sphaeriidae: *Pisidium* and *Sphaerium*), the Asiatic Clam, *Corbicula fluminea* (Corbiculidae) and four genera of mussels (Unionidae). Because several species of mussels are considered rare both nationally and by DNR's Wildlife and Heritage Service, this chapter includes expanded information about this important group of benthic macroinvertebrates.

Mussels

North America has a higher diversity of freshwater mussels than anywhere else in the world, once boasting nearly 300 species. Recent studies, however, estimate 35-55% of the continent's mussel fauna to be extinct, threatened, or endangered (Master, 1990, Biggins and Butler, 2000).

A total of 16 freshwater unionid bivalve species are reported in Maryland (Table 9-7). Of these, 14 are considered rare and are actively tracked by DNR's Wildlife and Heritage Service. The dwarf wedge mussel, *Alasmidonta heterodon*, has been classified as Federally Endangered and is known from only three creeks in Maryland. The dwarf wedge mussel is also classified as Endangered within the State along with *A. undulata*, *A. varicosa*, and *Lasmigona subviridis*. In addition, *Strophitus undulatus* has been listed as a species at risk of becoming threatened.

Throughout the United States, native freshwater mussels are imperiled by various habitat disturbances including pollution, habitat loss, and competition with invasive species. Human activity has had a tremendous effect on mussels in Maryland. The increase in impervious surfaces due to urbanization, loss of riparian buffer and other natural erosion controls, agricultural activity in and adjacent to waterways, and human pollution in general have contributed to the degradation of mussel habitat statewide. Another significant cause of habitat loss is the construction of impoundments, which alter the deposition of silt, hinder the movement of migratory species, and change the physical makeup of Maryland's streams and rivers (Hart, et al. 2002). Many freshwater mussels prefer waterways with moderate to high velocity, which become slowed by the construction of dams (Ortmann, 1919; Bogan and Proch 1997). Some mussels may have traditionally depended on migratory species as hosts during their parasitic life stage prior to developing into juvenile mussels (Watters 1994). When host fish species have declined or been totally eliminated from their native habitat, declines in mussels have resulted as well.

Table 9-7. Freshwater mussel species of Maryland. Compiled by DNR Wildlife and Heritage Service

Scientific Name	Common Name
Alasmidonta heterodon	Dwarf wedge mussel
Alasmidonta undulata	Triangle floater
Alasmidonta varicosa	Brook floater
Anodonta implicata	Alewife floater
Elliptio complanata	Eastern elliptio
Elliptio fisheriana	Northern lance
Elliptio lanceolata	Yellow lance
Elliptio producta	Atlantic spike
Lampsilis radiata	Eastern lampmussel
Lasmigona subviridis	Green floater
Leptodea ochracea	Tidewater mucket
Ligumia nasuta	Eastern pondmussel
Pyganodon cataracta	Eastern floater
Strophitus undulatus	Squawfoot
Utterbackia imbecillis	Paper pondshell

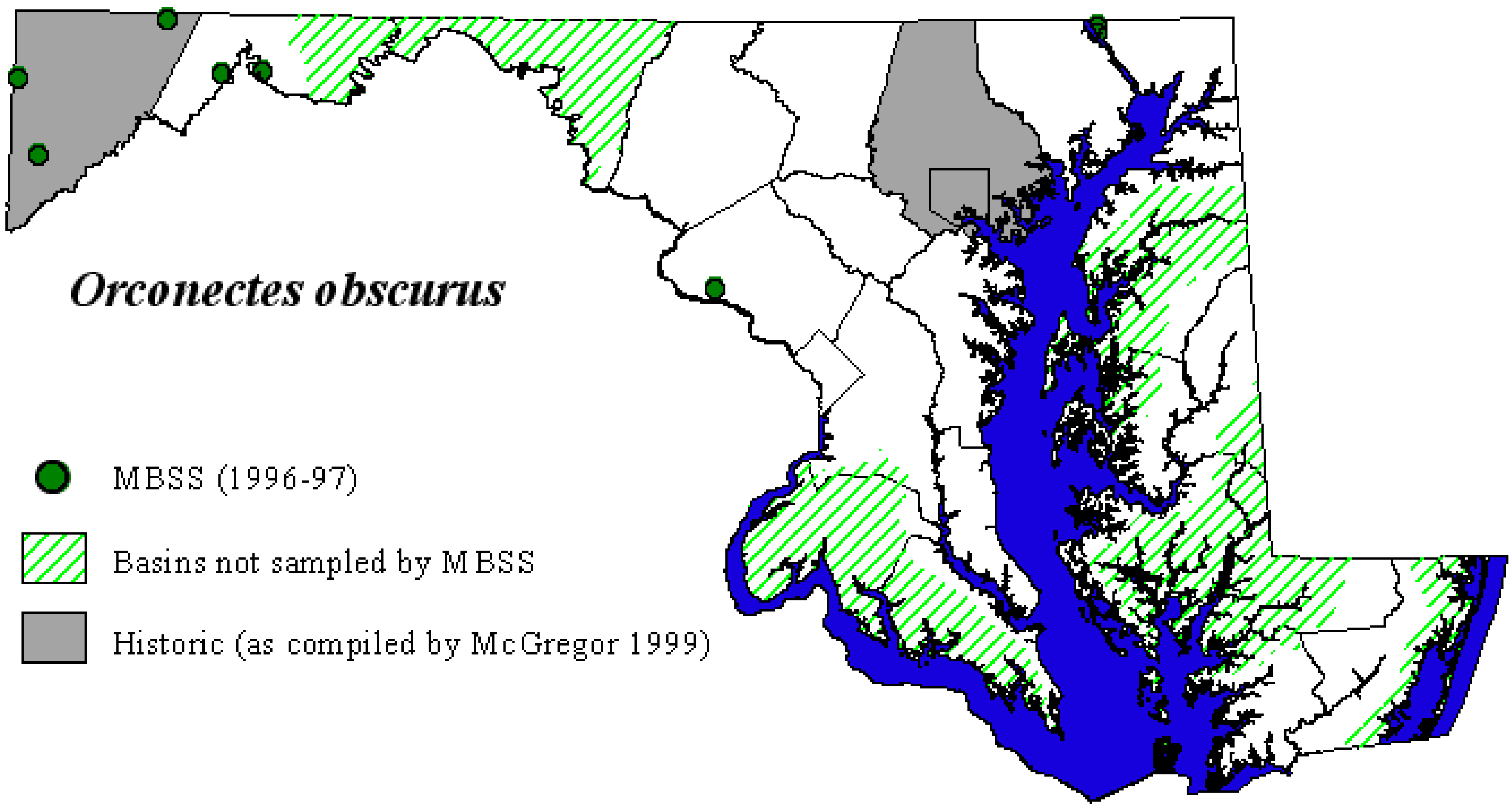


Figure 9-36. Historic and current distribution of the crayfish *Orconectes obscurus* in Maryland based on historic distribution reported in McGregor (1999) and the 1996-1997 MBSS

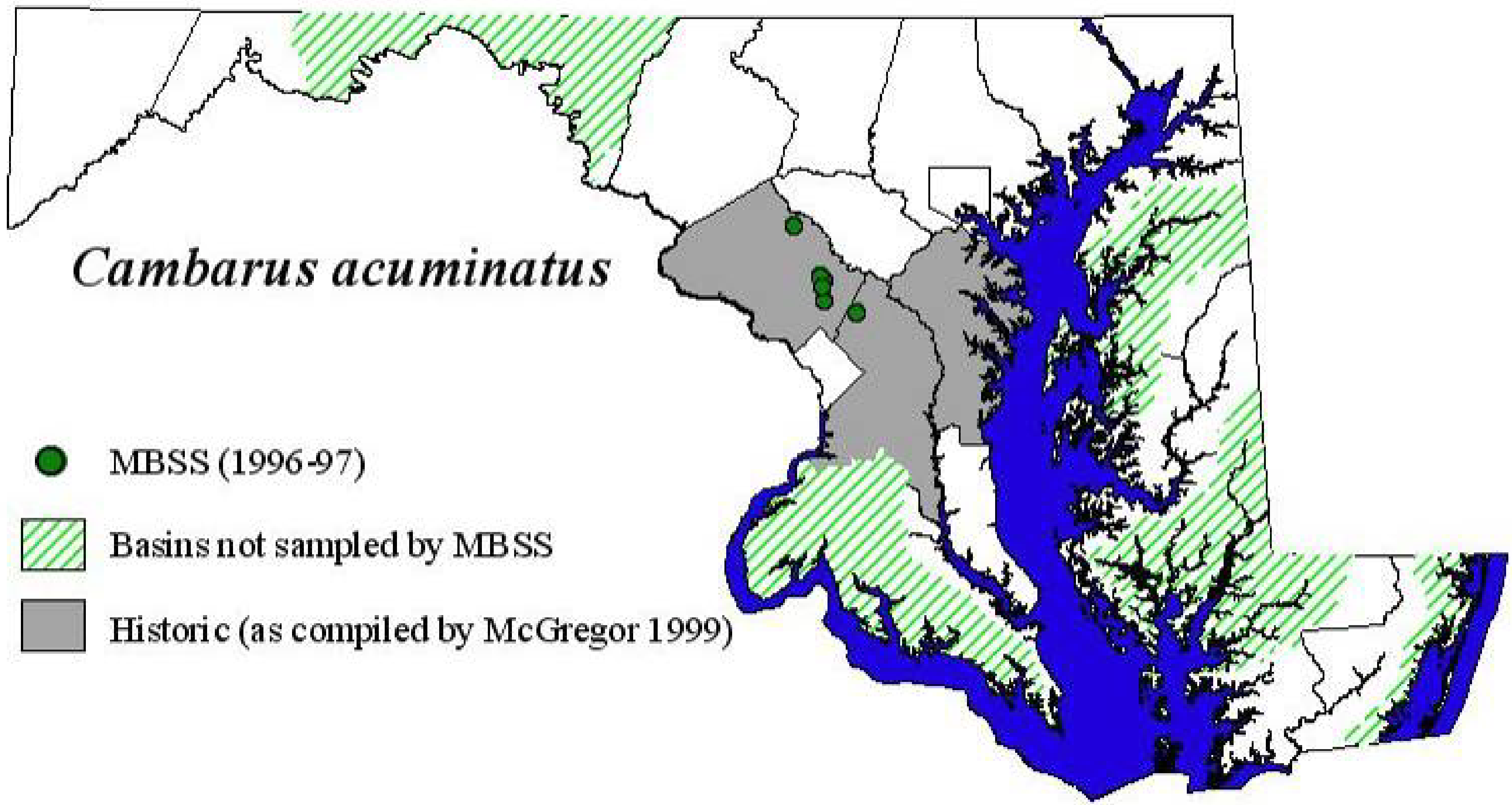


Figure 9-37. Historic and current distribution of the crayfish *Cambarus acuminatus* in Maryland based on historic distribution reported in McGregor (1999) and the 1996-1997 MBSS

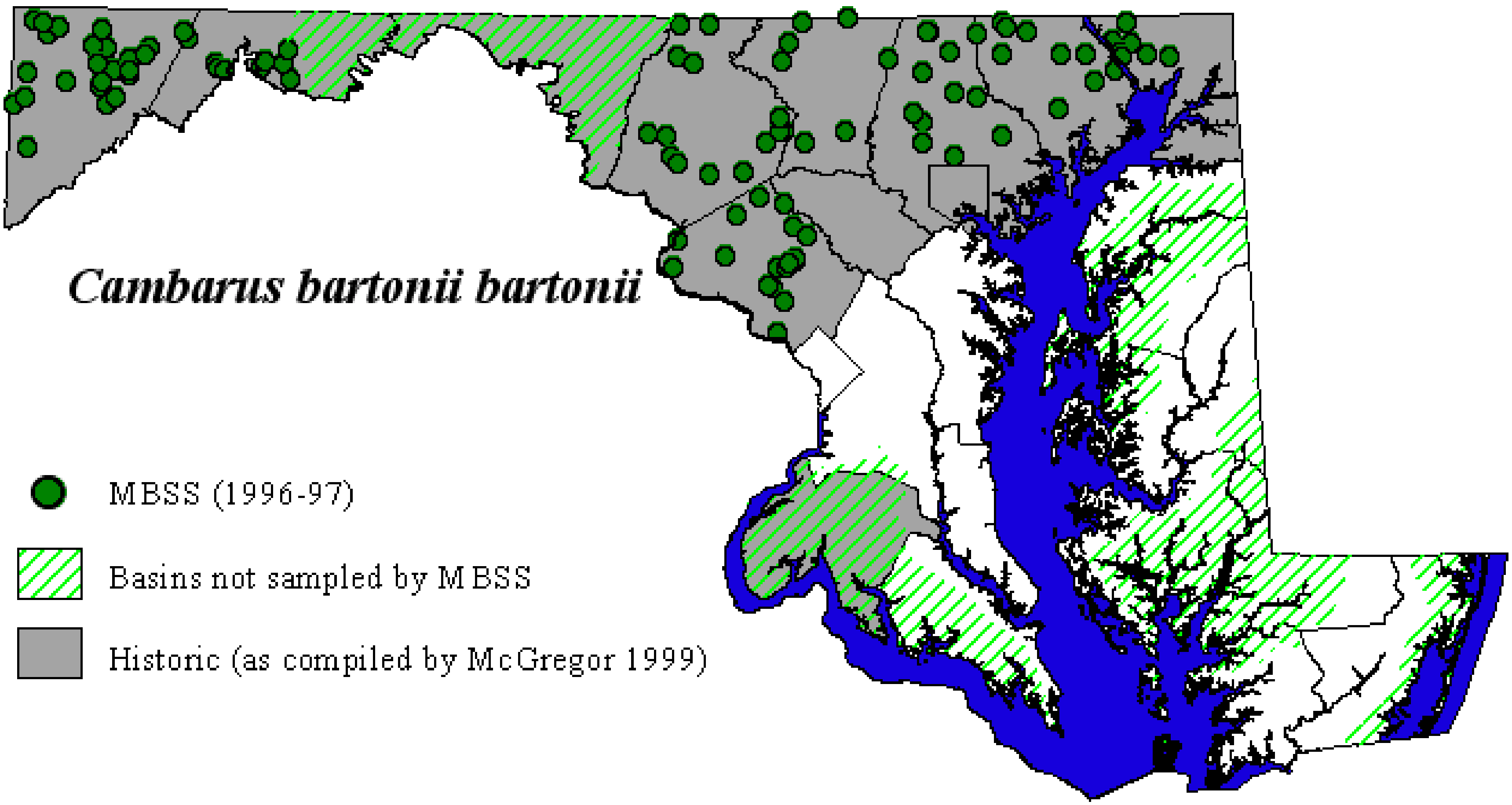


Figure 9-38. Historic and current distribution of the crayfish *Cambarus bartonii bartonii* in Maryland based on historic distribution reported in McGregor (1999) and the 1996-1997 MBSS

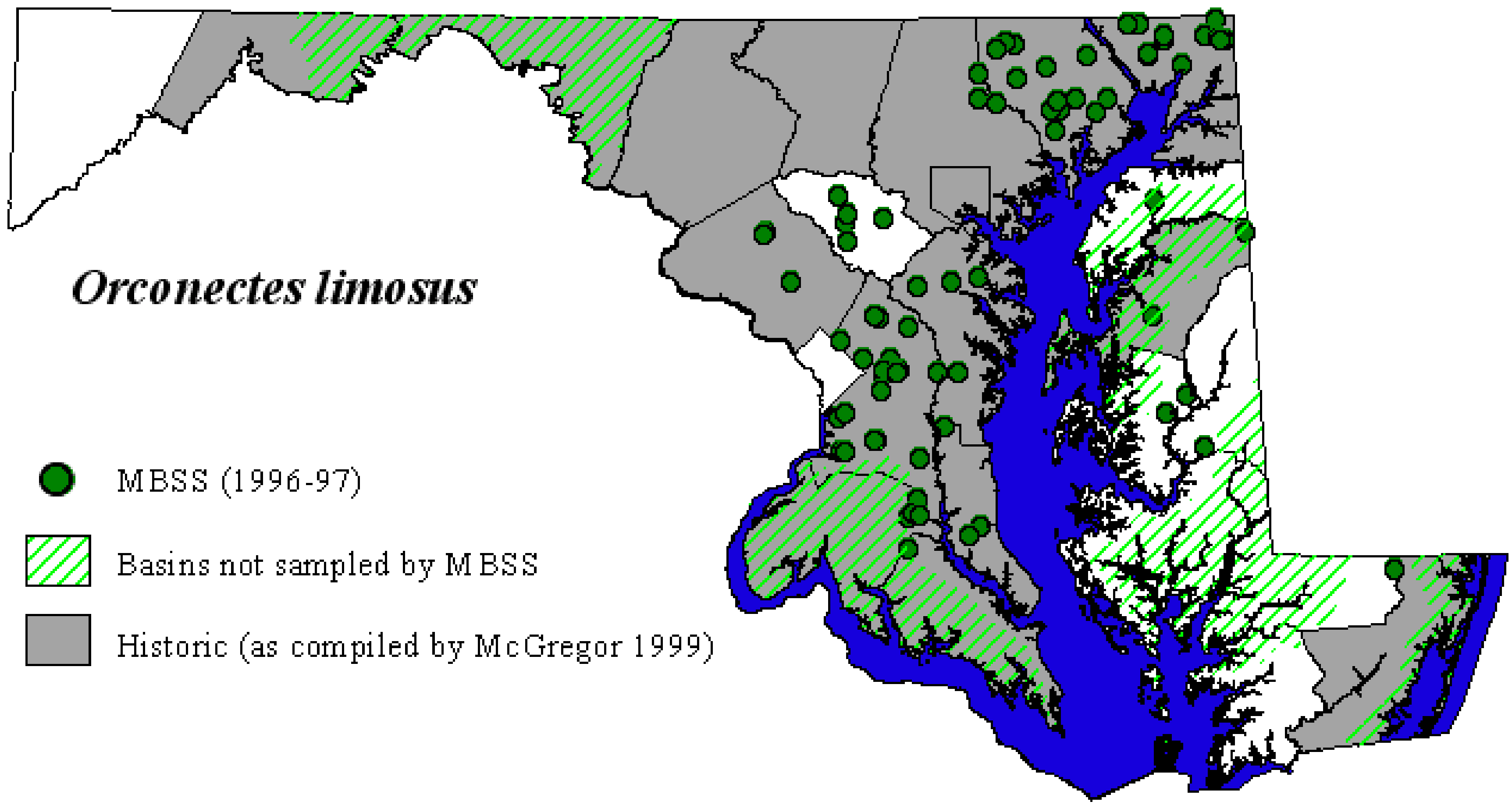


Figure 9-39. Historic and current distribution of the crayfish *Orconectes limosus* in Maryland based on historic distribution reported in McGregor (1999) and the 1996-1997 MBSS

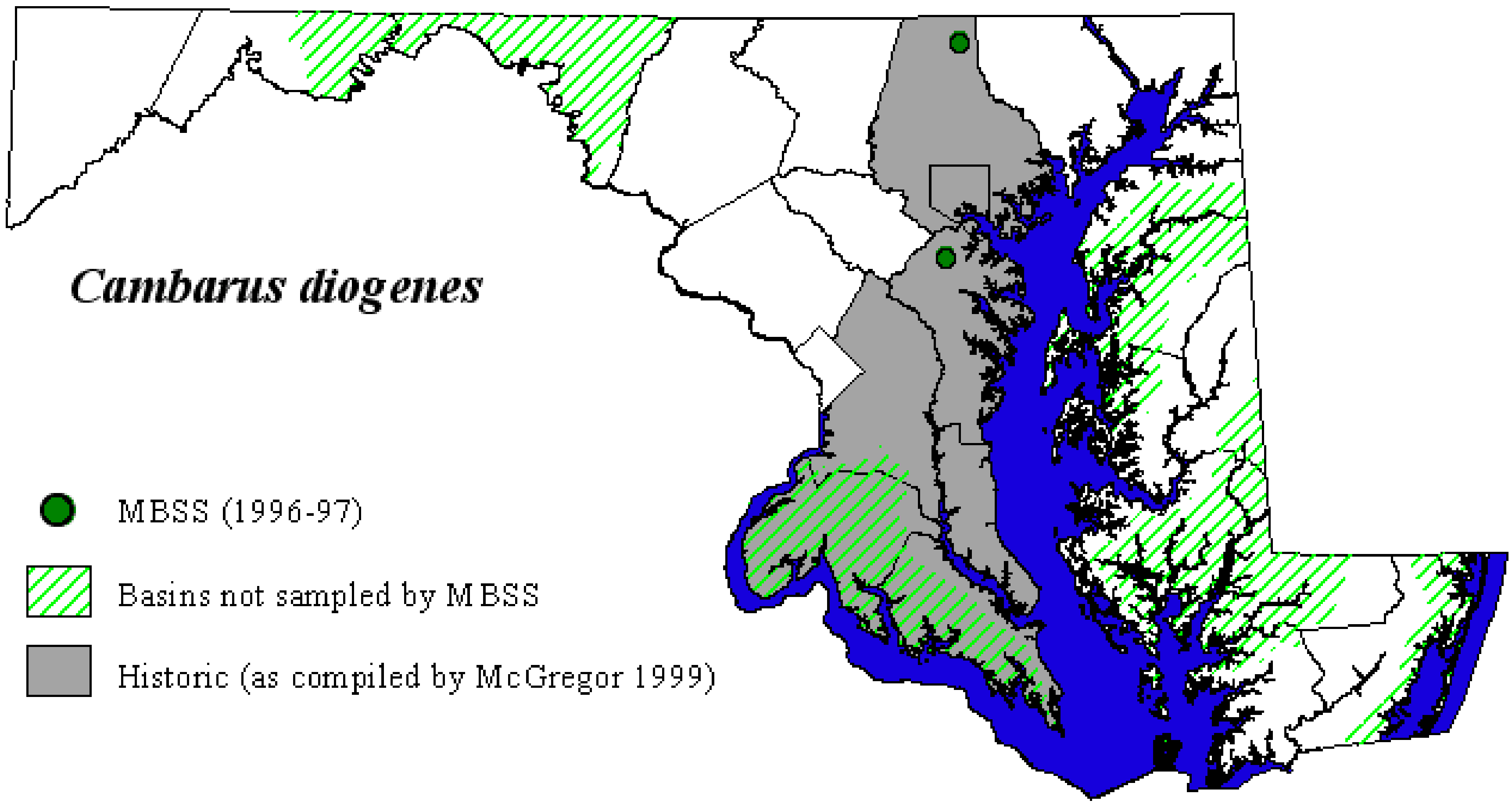


Figure 9-40. Historic and current distribution of the crayfish *Cambarus diogenes* in Maryland, based on historic distribution reported in McGregor (1999) and the 1996-1997 MBSS

In the eastern United States, invasive unionid species have also contributed to the reduction in diversity of native freshwater mussels. The Asiatic clam, *Corbicula fluminea*, and the zebra mussel, *Dreissena polymorpha,* are two non-native mollusks currently inhabiting the Chesapeake Bay watershed. Each of these species is capable of out-competing Maryland bivalves for food and habitat resources (Strayer and Smith, 1996). At present, only the Asiatic clam is confirmed to occur in Maryland waters.

During MBSS sampling from 1995 to 1997, freshwater mussels were observed at 128 or 18% of the core MBSS sites sampled statewide. Mussels were identified and recorded during habitat evaluation, benthic sampling, and fish sampling. Seven of the sixteen native unionid species were observed, including *A. implicata*, *E. producta*, *E. complanata*, *P. cataracta*, *E. fisheriana*, *E. lanceolata,* and *S. undulatus*. Mussel species richness was highest in several watersheds in the Potomac River, Chester, and Pocomoke river basins (Figure 9-41). The invasive Asiatic clam was also observed during the survey, often coincident with native freshwater mussels. Based on data collected during the MBSS in combination with data provided by the Maryland Natural Heritage Program, several strongholds for mussels remain in Maryland (Figure 9-42). These include portions of the Potomac River, the Corsica River, the upper Chester River, Southeast Creek, and Sideling Hill Creek.

9.5.4 Benthic Macroinvertebrate Assemblages

The following grouping of stream habitat types – Coastal Plain, Eastern Piedmont, and Highland - is largely based on analyses of MBSS benthic data using cluster analyses performed during the development of DNR's benthic and fish Indices of Biotic Integrity (Southerland et al. 2005). These analyses were all based on the taxa/abundance matrix for minimally impaired (reference) sites sampled from 1995 to 2004. A cluster analysis of sentinel site data using benthic macroinvertebrate assemblages provides additional information on finer-scale habitat types within these broad geographic areas (Figure 9-43).

9.5.4.1 Coastal Plain Streams

Streams on Maryland's Coastal Plain can be generally described as either blackwater or non-blackwater. Blackwater streams usually have an intimate connection with wetlands and dissolved organic carbon levels greater than 8 mg/L. They are also typically acidic, slow moving, and often braided. In contrast, non-blackwater streams have higher pH, dissolved organic carbon levels less than 8 mg/L and are often found at higher elevations (> 15m) and may be of higher gradient (> 0.5%). For the following discussion, we used a subset of minimally disturbed sites (sentinel sites and sites meeting reference criteria) (Southerland et al. 2005) to characterize benthic macroinvertebrate assemblages of high-quality streams.

Benthic assemblages in high-quality blackwater streams of the Coastal Plain appear to be biologically different than those of comparable high-quality streams in other Coastal Plain areas (Figure 9-43). Blackwater streams were often dominated by the dipterans *Stegopterna* (Simuliidae), Orthocladinae non-biting midges such as *Rheocricotopus, Zalutschia,* and *Orthocladius,* and the isopod *Caecidotea*. In addition, high-quality blackwater streams generally contained few mayfly, stonefly, and caddisfly taxa compared with such sites in non-blackwater Coastal Plain streams (Figures 9-30, 9-31, and 9-32).

The assemblages of these two stream types also contain mutually exclusive taxa. In high-quality non-blackwater Coastal Plain streams, *Haploperla* (Plecoptera), and *Optioservus* (Coleoptera) were commonly found, but never associated with high-quality blackwater streams. Conversely, the chironomids *Zalutschia* and *Dicrotendipes* were frequently found in blackwater streams but were not found in non-blackwater Coastal Plain streams.

9.5.4.2 Non-Coastal Plain Streams

Cluster analyses using sentinel site data also indicate that non-Coastal Plain streams can be subdivided into Piedmont and Coldwater systems. Further analyses of data from high-quality limestone streams, along with studies conducted in Pennsylvania (Glazier and Gooch 1987), suggest that benthic macroinvertebrate assemblages in limestone streams are dissimilar from Coldwater and Piedmont streams.

Limestone Streams

Benthic assemblages in limestone streams are generally different from those in freestone streams. Although most Maryland stream benthic assemblages tend to be dominated by insects, those in limestone streams are often dominated by non-insects such as amphipods, isopods, gastropods, and flatworms (Glazier 1991, Glazier and Gooch 1987, Meffe and Marsh 1983, Lorbinske, et al. 1997). While the overall abundance of benthic macroinvertebrates tends to be relatively high in limestone springs and streams, diversity tends to be low due to thermal constancy (Glazier 1991, Glazier and Gooch 1987, Ward and Dufford 1979). Compared with other high-quality freestone streams in this area, crustaceans such as *Lirceus* and *Gammarus* occurred more often, and in large numbers, in limestone streams. The insects most often associated with limestone streams were the chironomid *Parametriocnemus,* the mayfly *Ephemerella*, and the black fly *Prosimulium*.

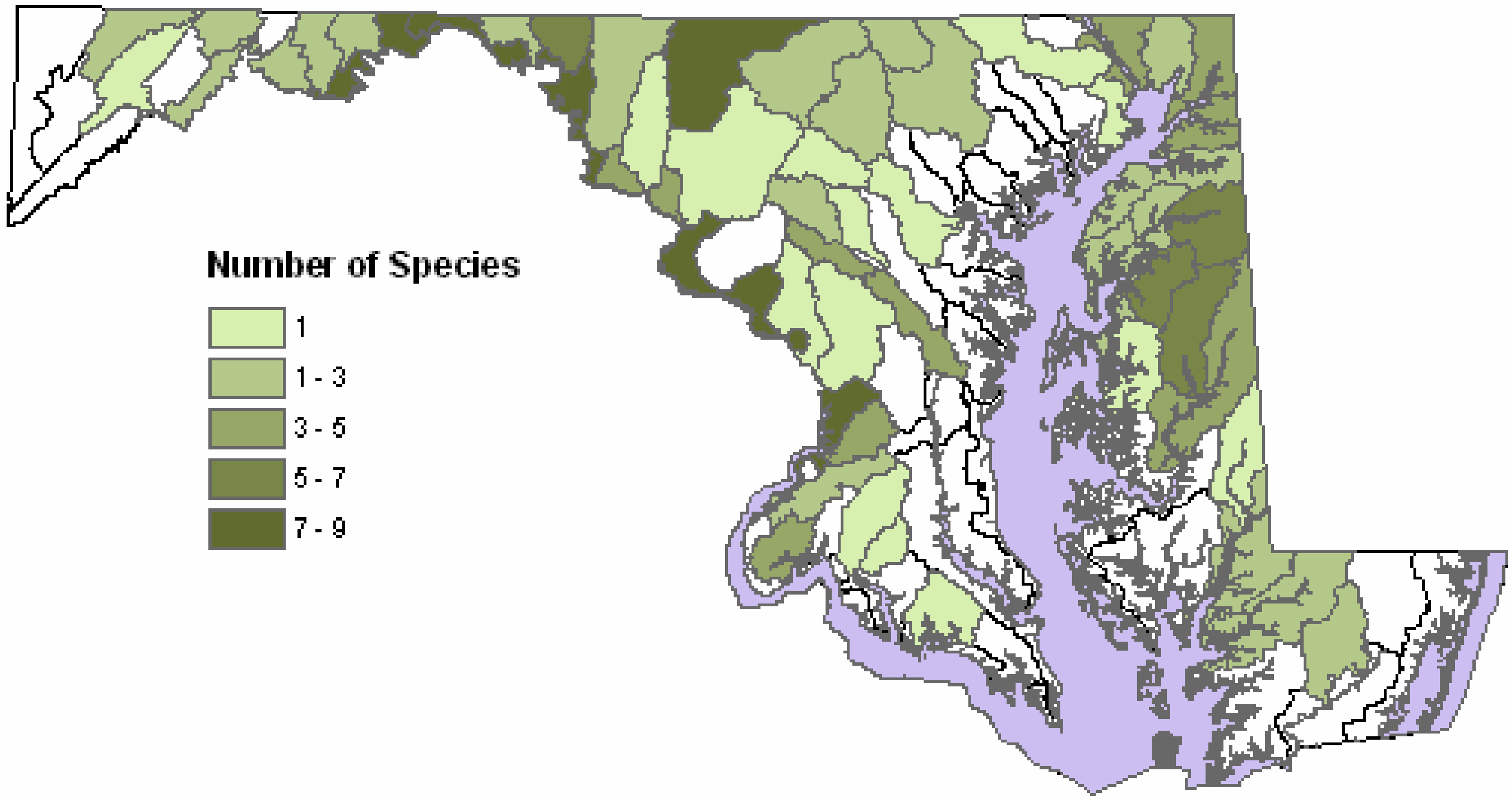


Figure 9-41. Freshwater mussel species richness in Maryland's watersheds. Data from 1995-2004 MBSS and DNR's Wildlife and Heritage Service.

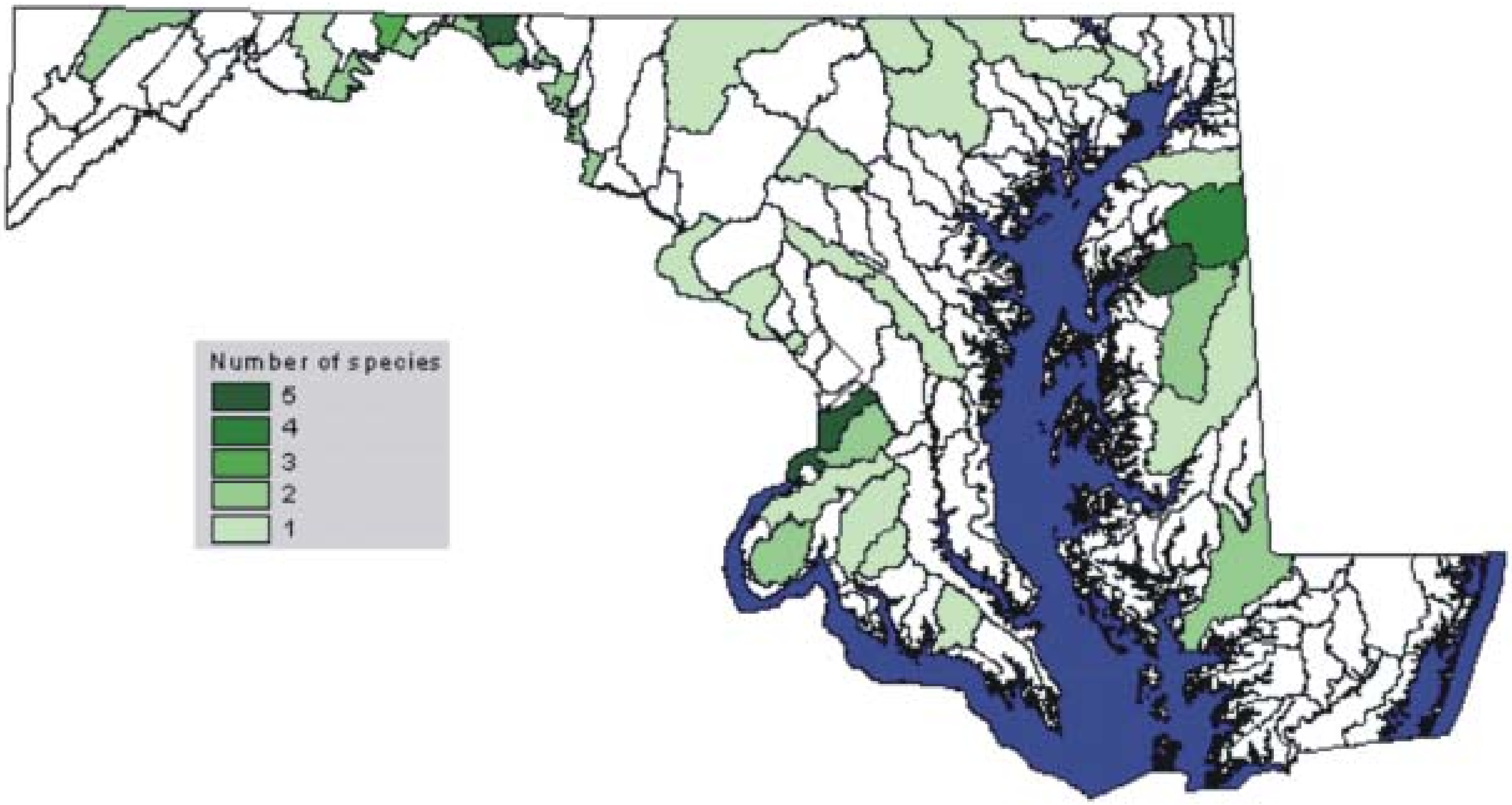


Figure 9-42. Freshwater GCN mussel strongholds in Maryland. Data from DNR's Wildlife and Heritage Service. Darker colors indicate strongholds for multiple species.

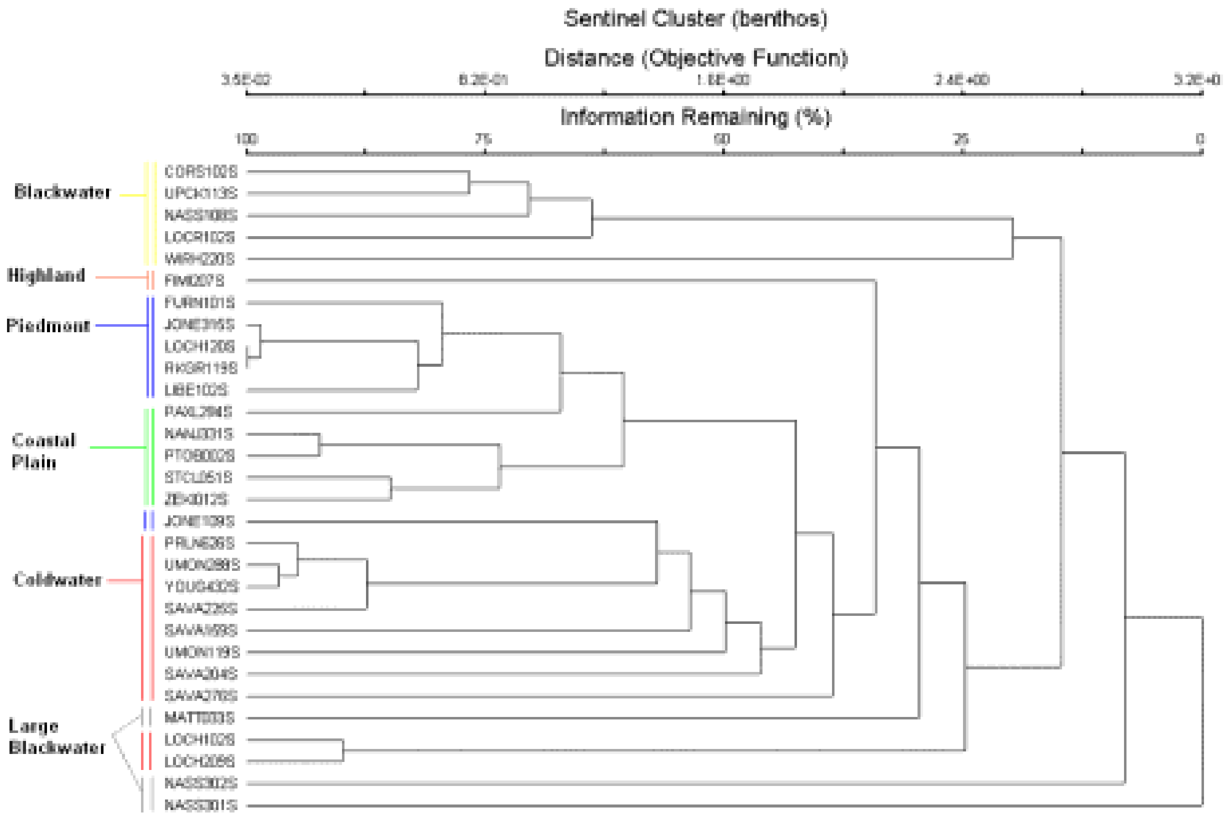


Figure 9-43. Cluster diagram of benthic macroinvertebrates in Maryland streams. Based on 1995-2004 MBSS sentinel sites.

Piedmont Streams

The black fly *Prosimulium* and the mayfly *Ephemerella* often dominated benthic macroinvertebrate communities in high-quality Piedmont streams. Because these two taxa were commonly found in such high relative abundances, benthic macroinvertebrate sub-samples were typically characterized by lower measures of assemblage evenness compared to most of the other key habitat types (Figure 9-41). The chironomid *Orthocladius*, along with the nemourid stoneflies *Amphinemura* and *Prostoia* were also found at high-quality Piedmont streams. The number of these insects collected, however, was an order of magnitude lower than those of the dominant taxon. *Cheumatopsyche* and *Hydropsyche* were the most abundant and frequently collected caddisfly taxa in Piedmont streams.

Coldwater Streams

High-quality coldwater streams typically support more genera of stoneflies (Plecoptera) than the other stream types. As many as 25 genera were collected in high-quality coldwater streams, compared to just 14, 13, and 8 in Piedmont, non-blackwater Coastal Plain, and Blackwater streams respectively. Stoneflies associated with these coldwater streams include *Malirekus, Cultus,* and *Yugus* (Perlodidae), and *Paragnetina* and *Eccoptura* (Perlidae). *Ephemerella* was the most abundant mayfly in coldwater streams; it was, however, not as large a component of the assemblage as in Piedmont streams. The mayflies *Epeorus* and *Paraleptophlebia* were the second and third most frequently collected and abundant taxa in high-quality coldwater streams. The relative abundances of these taxa were 13th and 36th respectively in Piedmont streams. *Diplectrona* and *Neophylax* were the most abundant and frequently collected caddisfly taxa in high-quality coldwater streams.

The single MBSS site with pH less than 4.0 (3.6) was on Three Forks Run in the Potomac River Upper North Branch watershed in Garrett County. The stream is subject to acid mine drainage. Both fish and benthic Indices of Biotic Integrity rated the stream as Very Poor.

9.5.5 Response to Human Disturbance

Maryland's benthic macroinvertebrates are exposed to a complex array of chemical, physical, and biological stressors, and due to their relative lack of mobility, may be more vulnerable to environmental stressors than fishes or herpetofauna. Benthic macroinvertebrates are intimately associated with stream substrates during most of their life cycles, so stream habitat damage, even at the micro scale, may have important implications for survival. Lastly, since many benthic macroinvertebrates are primary consumers, impairments to stream flora or sources of streamside allochthonous material, such as trees and shrubs, may directly impact these animals more so than their vertebrate neighbors.

The MBSS database provides a wealth of information on stressors to stream benthos, and impacts resulting from these stressors can be evaluated in numerous ways. Although a comprehensive treatment of all stream stressors assessed by MBSS is beyond the scope of this report, several prominent examples are included here.

One simple and straightforward example is the impact of stressors to taxa richness within a sample. For pH, the mean number of benthic taxa was highest when pH ranged from 6.0 to 7.0 (Figure 9-44). Acidified streams, as expected, support fewer taxa. For example, streams in the Casselman River, Deep Creek Lake, Georges Creek, Potomac River Upper North Branch, and Wills Creek watersheds that receive acid mine drainage (AMD) supported an average of 15 taxa. Non-AMD streams in the same watersheds supported an average of 22 taxa (Figure 9-45). It is important to note that blackwater streams have naturally low pH and only when pH is excessively low is it an anthropogenic stressor there.

One MBSS physical habitat measure that may directly reflect impairments to benthic assemblages is epifaunal substrate - the quality, variety, and abundance of stable substrates available for benthic colonization. Given that mayflies are generally sensitive to chemical and physical habitat disturbance, this order of aquatic insects is often used as an indicator of stream habitat quality. The mean percent of mayfly individuals per site was highly correlated with MBSS epifaunal substrate ratings (Figure 9-46). When epifaunal substrate was in the poor category, the mean % Ephemeroptera individuals per sample was seven. This number climbed to 22 when epifaunal substrate was rated optimal. Clearly, impacts to stream habitats, as measured by the quality of epifaunal substrate, have a direct impact on the percentage of sensitive organisms in a sample.

Like mayflies, stoneflies and caddisflies are considered sensitive to stream disturbance. One metric, the EPT Index, is commonly used as an indicator of benthic assemblage condition. This index is simply the number of different mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa in a benthic sample. In steams with less than 10% impervious surface, the mean

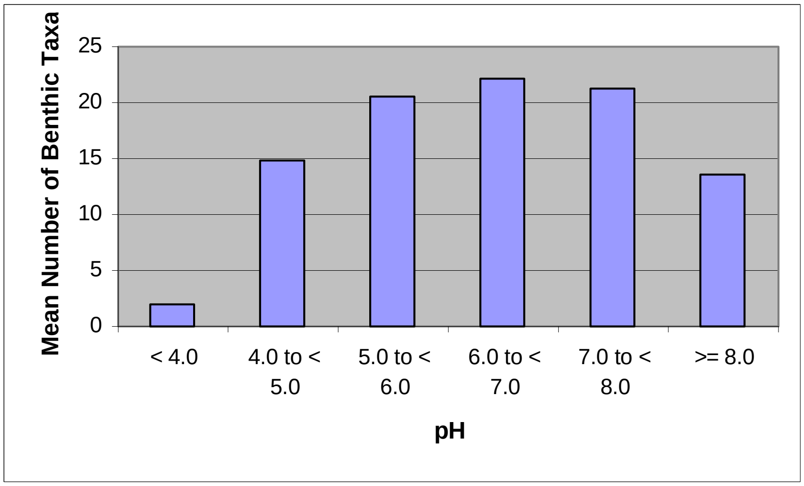


Figure 9-44. Mean number of benthic taxa per site, by pH category, based on data from the 1994-2004 MBSS

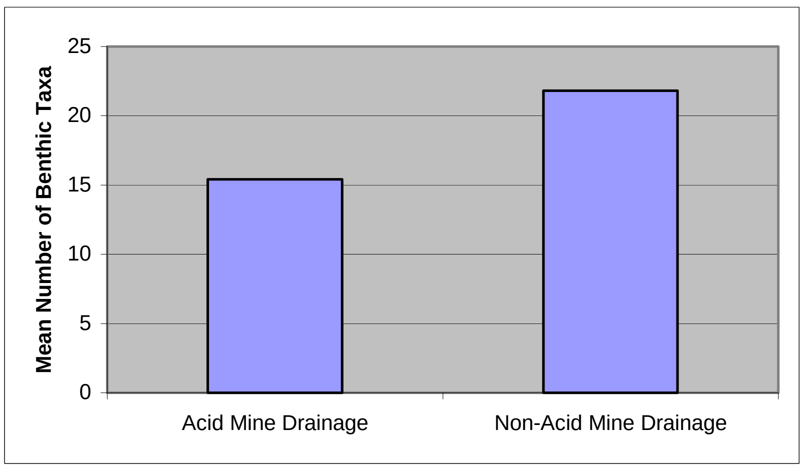


Figure 9-45. Mean number of benthic taxa per site in acid mine drainage and non-acid mine drainage sites in the Casselman River, Potomac River upper North Branch, Deep Creek Lake, Georges Creek and Wills Creek watersheds. Based on data from the 1994-2004 MBSS.

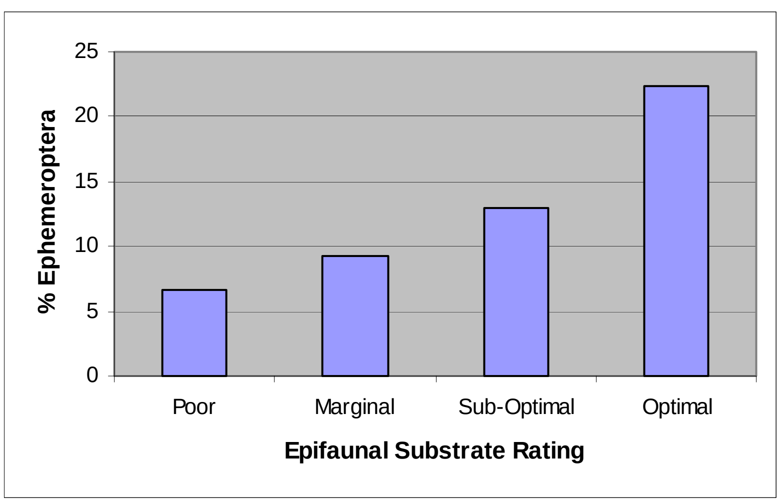


Figure 9-46. Percent Ephemeroptera per site by epifaunal substrate rating based on data from the 1994-2004 MBSS

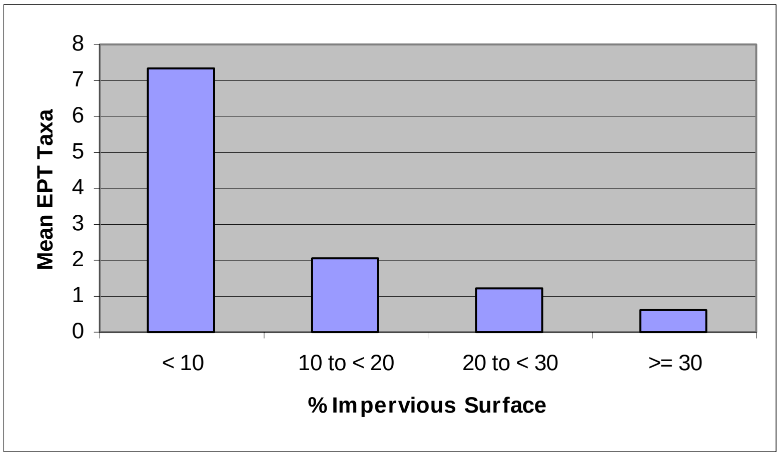


Figure 9-47. Number of Ephemeroptera, Plecoptera, and Trichoptera taxa per site and % impervious surface in the upstream catchment based on data from the 1994-2004 MBSS

EPT Index was greater than 7 (Figure 9-47). At the other extreme, streams with more than 30% impervious surface had a mean EPT Index of less than one. Thus, the number of sensitive benthic taxa, as measured by the EPT Index, declines as the proportion of a watershed is urbanized.

Another approach to evaluate the response of benthos to human disturbance is to examine the range of a particular stressor at which individual taxa were found. Select genera within the orders Diptera, Trichoptera, Plecoptera, and Ephemeroptera were chosen to demonstrate how, within an order and across orders, certain genera are tolerant to stress (wide bar), while others are not (narrow bar). For example, the chironomid *Orthocladius* was found from pH 4.0 to 9.7, a range of over five pH units. Conversely, the mayfly *Drunella* was found at a relatively narrow range of only about two pH units (6.7 to 8.6) (Figure 9-48). Since *Drunella* was never found at pH below 6.7, this insect should be considered "at risk" in streams subject to acid mine drainage or other atmospheric deposition of acid.

MBSS data can also provide insight into the sensitivities of individual benthic genera to low dissolved oxygen (DO) levels. *Drunella* and the stonefly *Pteronarcys* are both sensitive to low DO; these taxa were never found at levels below 6 mg/L (Figure 9-49). In contrast, genera found at very low DO levels include *Orthocladius* (Diptera) (0.3 mg/L), *Limnophyes* (Diptera) (0.4 mg/L), *Cheumatopsyche* (Trichoptera) (0.3 mg/L), and *Ephemerella* (Ephemeroptera) (0.3 mg/L).

Many benthic taxa are sensitive to the disturbances associated with upstream impervious surface **(**Figure 9-50). For example, *Drunella* and the *Pteronarcys* were never found in watersheds with more than 4% impervious surface, while *Orthocladius* and the caddisflies *Hydropsyche* and *Cheumatopsyche* were both found at sites where imperviousness exceeded 35%.

The examples illustrated above provide clear evidence of the impact of human disturbance on benthic macro-invertebrate biodiversity. Future analyses may help to more precisely define thresholds of human activity beyond which biological impacts become irreversible, and also allow for reliable prediction of levels at which species and genera will be lost from the State.

MOST ABUNDANT BENTHIC SITE: Buck Branch in Harford County contained the highest density of benthic macroinvertebrates during the 1994 – 2004 MBSS. An estimated 890 organisms per square foot comprising 20 taxa were collected from a sample of 20 square feet of best available habitat. These data yielded a benthic IBI score of 4.7. Landuse in the watershed is dominated by agriculture (76%) and contains no urban land use or impervious surface. The Physical Habitat Index score for this site was 63 out of 100. It is possible that runoff from agricultural lands may cause nutrient enrichment and therefore, increased densities of benthic macroinvertebrates.

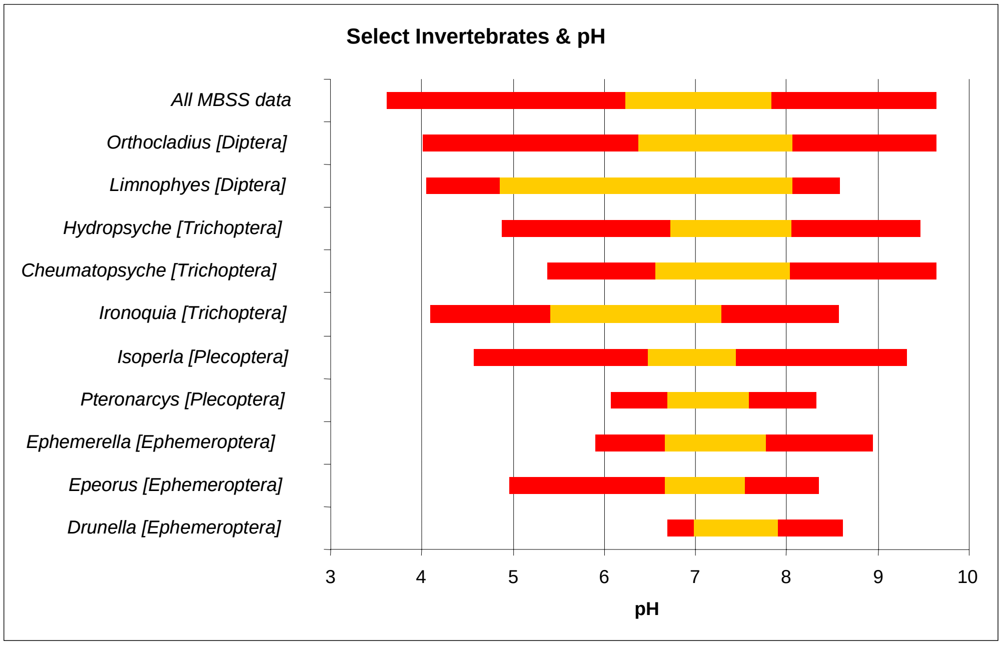


Figure 9-48. Examples of benthic macroinvertebrate genera and the range of pH at which they occurred. Red indicates 10th and 90th percentiles; data from 1994-2004 MBSS.

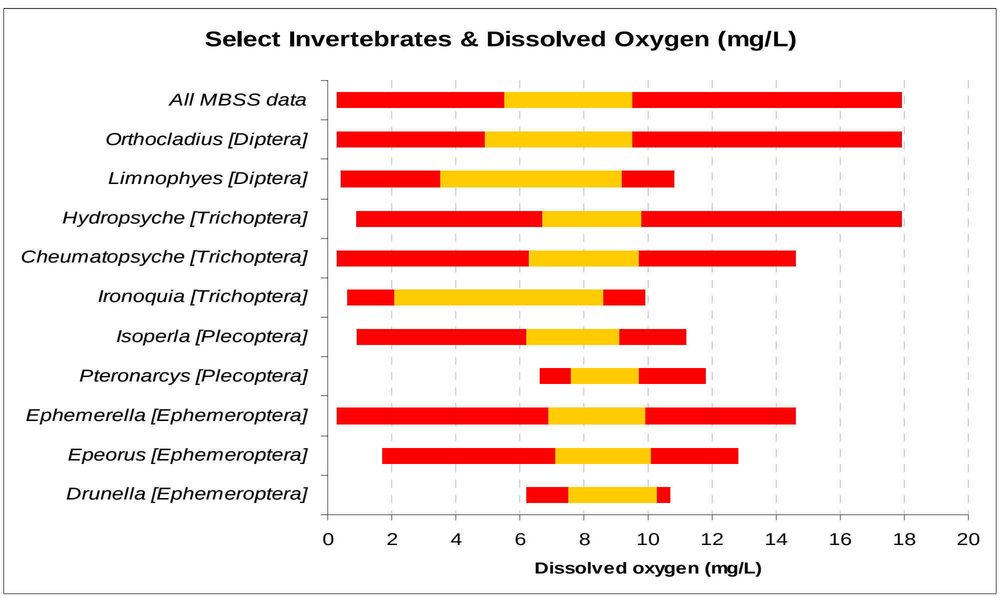


Figure 9-49. Examples of benthic macroinvertebrate genera and the range of dissolved oxygen at which they occurred. Red indicates 10th and 90th percentiles; data from 1994-2004 MBSS.

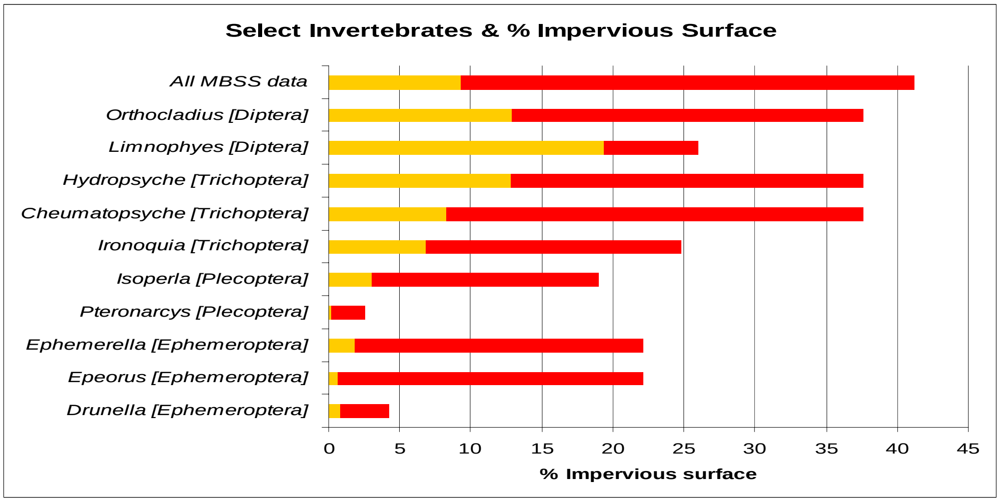


Figure 9-50. Examples of benthic macroinvertebrate genera and the range of % upstream imperviousness at which they occurred. Red indicates 90th percentile; data from 1994-2004 MBSS.

RICHEST BENTHIC COMMUNITY: Mill Creek in Cecil County supported the richest benthic macroinvertebrate community during MBSS sampling from 1994 – 2004. An impressive 45 taxa were collected from a 100 specimen sub-sample. Genera from the Chironomidae family dominated the community composition with 17 genera. This site scored among the highest in the Coastal Plain in terms of the Benthic Index of Biotic Integrity at 4.7. The Physical Habitat Index score for this site was 55 out of 100.

9.6 HIGH AND LOW INTEGRITY STREAMS

Of approximately 2300 sites sampled during the 1994 – 2004 MBSS, only 55 sites met the criteria developed to define high integrity streams (Figure 9-51). The majority of these (44) were located in the Highland physiographic province, followed by 6 sites in the Coastal Plain and 5 in the Eastern Piedmont. Of particular note was a site in Timber Run in the Liberty Reservoir watershed, which in 2000 had a Combined Biotic Index score of 5.0. In subsequent years, the CBI score at this site has fluctuated from 4.0 to 4.83.

The majority of the higher integrity sites were distinguished by the fact that urban land use and therefore the amount of impervious surface in these watersheds was low. On average, watersheds draining to these sites had only 1.0% urban land use and 0.3% imperviousness. Similarly, nutrient enrichment, in the form of mean nitrate-nitrogen, was only 0.55 mg/L.

A total of 49 sites met the criteria for lowest integrity streams (Figure 9-51). Twenty sites were located on the western shore of the Coastal Plain, followed by 19 Eastern Piedmont and nine Highland sites. Only a single site in Wagram Swamp Branch on the eastern shore of Maryland was classified as being among the very worst in Maryland. Low dissolved oxygen levels and a high degree of development in the watershed, as measured by the percent urban land use and impervious surface, most frequently characterized streams in the Coastal Plain and Eastern Piedmont. The most degraded sites in the Coastal Plain had an average dissolved oxygen level of 3.7 mg/L, while Eastern Piedmont sites were located in drainages with an average of 65% urban land use and 20% impervious surface. With the exception of one site, low

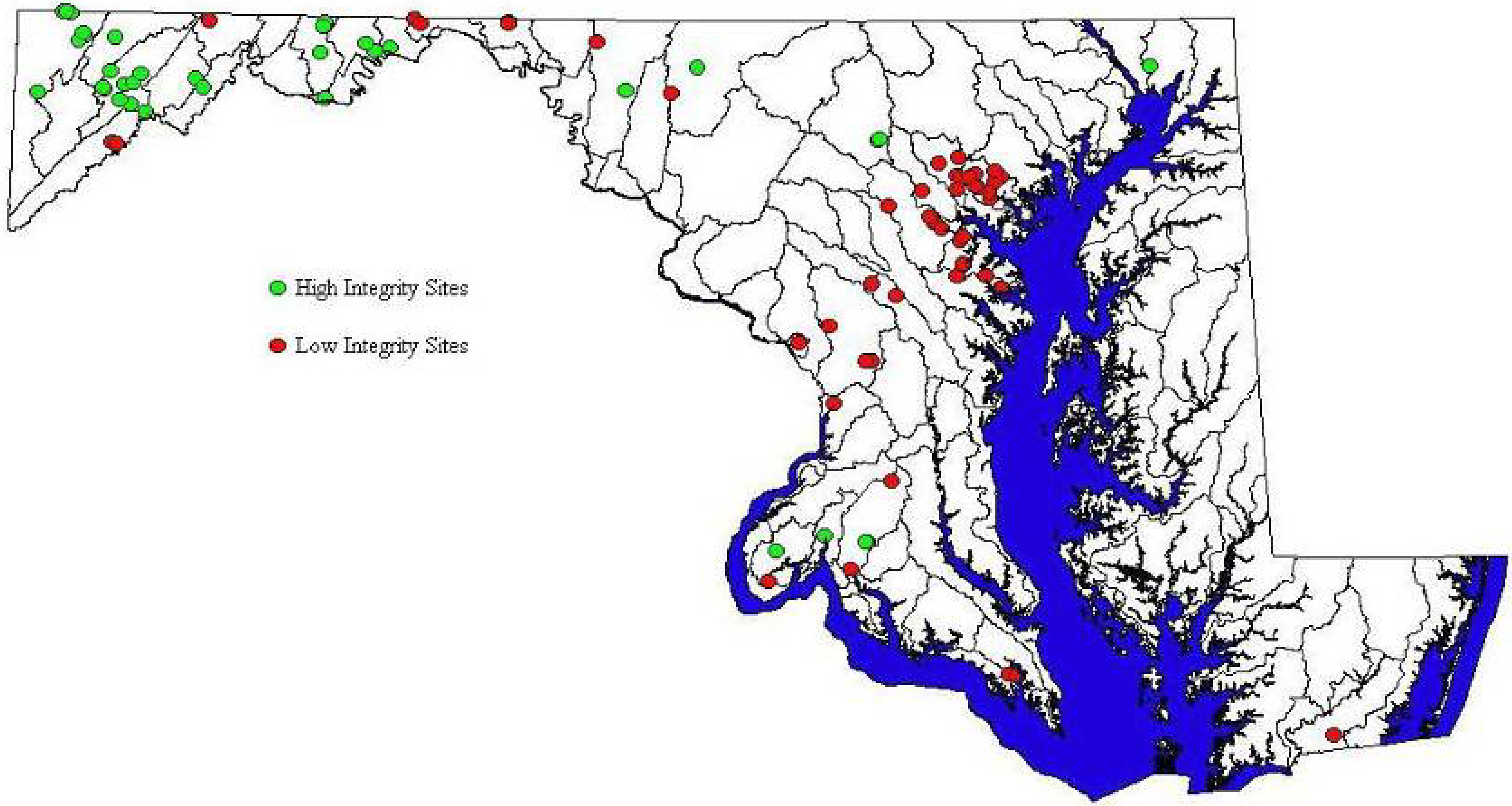


Figure 9-51. Location of highest and lowest integrity sites sampled during the 1994 – 2004 Maryland Biological Stream Survey (High integrity defined as CBI > 4; Forest Land Use > 75.0%; SO_4 < 50.0 mg/L; pH > 6.0 or Dissolved Organic Carbon > 8.0 mg/L; NO_3 < 4.0 mg/L; Dissolved Oxygen > 5.0 mg/L; Riparian Width ≥ 50 m; and Instream Habitat Score > 15. Lowest integrity defined as sites with CBI < 2, and meeting either: pH ≤ 5.0 and ANC ≤ 0 µeq/L; Dissolved Oxygen ≤ 2.0 mg/L; NO_3 > 7.0 mg/L and Dissolved Oxygen < 3.0 mg/L; Instream Habitat Score ≥ 5 and Urban Land Use > 50%; or Urban Land Use > 50% and Riparian Width = 0 m).

showed the effects of acid mine drainage and acid deposition. These sites were characterized by low pH (mean: 4.5) and low acid neutralizing capacity (mean: -68 μeq/L).

9.7 WATERSHED RANKING

No single approach is likely to protect all aspects of biodiversity in Maryland. Likewise, there is no single "right" method of portraying how biodiversity varies across the State and which areas are most important to focus habitat protection and/or restoration. Nonetheless, the reality of funding limitations and the urgent need for action dictate the development of a sound, scientifically based ranking of Maryland watersheds, for the purpose of conserving biodiversity in the flowing waters of Maryland.

INTEGRATING FRESHWATER AND ESTUARINE RESOURCE MANAGEMENT

Perhaps the largest ongoing natural resources restoration and protection effort in Maryland is associated with Chesapeake Bay, and there is a growing effort in the Coastal Bays region as well. In most cases, freshwater biodiversity is not specifically considered during placement and prioritization of estuarine-related restoration and protection projects. In this volume, a watershed-based system of stream and riverine biodiversity ranking is presented to provide a means to plan estuarine protection and restoration activities in locations where they would also benefit stream and river species. Given the historically low level of funding for biodiversity protection and restoration in Maryland and elsewhere, the potential benefit of incorporating freshwater biodiversity needs into other efforts is quite large.

However, it is important to note that although freshwater taxa are the most imperiled group of organisms in Maryland, other groups and individual species not typically found in stream and riverine habitats are also at high risk and constitute high priority targets for conservation. In addition, freshwater taxa that prefer habitats such as small wetlands may not be well characterized by the ranking system presented here. To conserve the full array of Maryland's flora and fauna, it is clearly necessary to use other, landscape-based tools and consider factors such as maintaining or reconnecting terrestrial travel corridors.

With this goal in mind, a number of biological attributes were used to rank each of the watersheds (PSUs) used for MBSS sampling in terms of their stream and riverine biodiversity. Because biodiversity includes both the variety of life and its processes, multiple aspects of biodiversity were used for classification, rather than ranking watersheds strictly on the number of rare species present or by their IBI scores. Also, recognizing that different assemblages might provide differing results in ranking, fishes, freshwater mussels, stream herpetofauna, and benthic macroinvertebrates were combined during the ranking process to provide an integrated view of each watershed.

First, a tiered watershed prioritization method was developed. Special emphasis was placed on state-listed stream and riverine species and stronghold watersheds for state-listed stream and riverine species. Fauna considered included stream salamanders, freshwater fishes, and freshwater mussels. Rare, pollution-sensitive benthic macroinvertebrates collected during the 1994-2004 MBSS were also used to identify the suite of watersheds necessary to conserve the full array of known stream and river biota in Maryland. A detailed description of the methods utilized to complete this ranking is found in: 2000-2004 Maryland Biological Stream Survey Volume 6: Laboratory, Field, and Analytical Methods (http://www/dnr/Maryland.gov/streams/pubs/ea05-3_method. pdf), and a Glossary of Terms is found at the back of this volume.

A total of 25 PSUs out of 84 were classified as Tier 1 [*Watersheds judged to be strongholds for one or more state-listed stream or riverine species*] (Figure 9-52; Table 9-8). Within this tier, the highest-ranking watershed in Maryland based on rarity ranking, biological "intactness", and migratory fish density was Zekiah Swamp in Charles County. Other watersheds in the top five were the Casselman River, Deer Creek, Youghiogheny River, and Corsica River/Southeast Creek.

Eleven (11) watersheds were classified as Tier 2 [*Watersheds judged to be strongholds for one or more non-state-listed stream or riverine GCN species that also had state-listed species present*]. Six additional watersheds were classified as Tier 3 [*Watersheds judged to be strongholds for one or more non-state-listed stream or riverine GCN species that did not have state-listed species present*], Another 6 watersheds were Tier 4 [*Non-stronghold watersheds that had state-listed species present*], and 14 more watersheds were classified as Tier 5 [*Watersheds that together with all higher ranked tiers were necessary to preserve all fish, mussel and stream herpetofauna species, plus rare, sensitive benthic taxa*].

The remaining 22 watersheds were in the final tier, Tier 6, [*all remaining watersheds meeting any of the criteria for the tiers describe previously*]. Based on rarity, intactness, and migratory fish density, the lowest ranking watersheds within this tier (and therefore in the State) were Catoctin Creek, West Chesapeake, Georges Creek, Potomac River Frederick County, and Middle Patuxent River. However, it should be noted that if the minimum number of watersheds necessary to conserve all stream benthic mile.

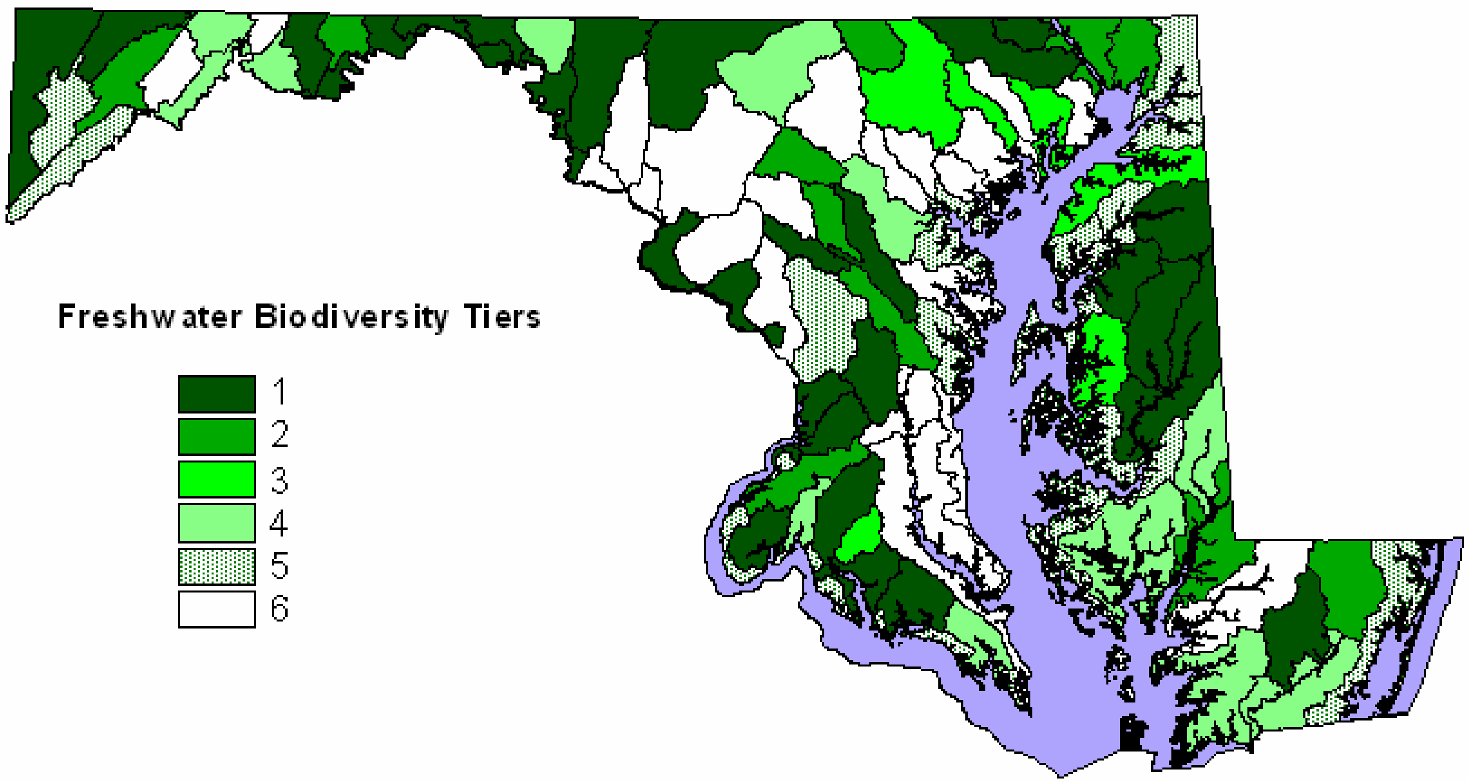


Figure 9-52. Freshwater stream and riverine biodiversity ranking for Maryland by watershed, based on strongholds, rarity, biological conservation units, assemblage intactness, and migratory fish use. Data from the 1994-2004 MBSS, Raesly unpub. data, Harris 1975, and the Maryland Natural Heritage Program database.

Table 9-8. Freshwater stream and riverine biodiversity ranking for Maryland by watershed, based on strongholds, rarity, biological conservation units, assemblage intactness, and migratory fish use. Data from the 1994-2004 MBSS, Raesly unpub. data, Harris 1975, Thompson 1984, and the Maryland Natural Heritage Program database. (BCU = Biological Conservation Unit, GCN = Greatest Conservation Need)

PSU NAME	Rarity	Biological Integrity	Migratory Fish	Average	BCU	GCN Stronghold	Listed Species Present	Listed Species Stronghold	Tier	Rank
Zekiah Swamp	0.23	0.51	1.00	0.58	Y	Y	Y	Y	1	1
Casselman River	0.95	0.65	0.00	0.53	Y	Y	Y	Y	1	2
Deer Creek	0.15	0.48	0.91	0.52	Y	Y	Y	Y	1	3
Youghiogheny River	1.00	0.46	0.00	0.49	Y	Y	Y	Y	1	4
Corsica River/Southeast Creek	0.21	0.75	0.33	0.43	Y	Y	Y	Y	1	5
Chester River Upper	0.23	0.63	0.33	0.40	Y	Y	Y	Y	1	6
Rocky Gorge Dam	0.17	0.79	0.07	0.34	Y	Y	Y	Y	1	7
Western Branch	0.44	0.28	0.22	0.31	Y	Y	Y	Y	1	8
Potomac River Montgomery County	0.42	0.41	0.06	0.29	Y	Y	Y	Y	1	9
Tuckahoe Creek	0.34	0.38	0.13	0.29	Y	Y	Y	Y	1	10
Nanjemoy Creek	0.21	0.51	0.13	0.28	Y	Y	Y	Y	1	11
Broad Creek	0.15	0.69	0.00	0.28	Y	Y	Y	Y	1	12
Breton Bay/St. Clements Bay	0.17	0.42	0.18	0.26	Y	Y	Y	Y	1	13
Monocacy River Upper	0.45	0.31	0.00	0.26	Y	Y	Y	Y	1	14
Piscataway Creek	0.12	0.43	0.18	0.24	Y	Y	Y	Y	1	15
Potomac Upper Tidal/Oxon Creek	0.21	0.13	0.26	0.20	Y	Y	Y	Y	1	16
Dividing Creek/Nassawango Creek	0.15	0.36	0.08	0.20	Y	Y	Y	Y	1	17
Potomac River Washington County/ Marsh Run/Tonoloway Creek/Little Tonoloway Creek	0.29	0.28	0.00	0.19	Y	Y	Y	Y	1	18
Wicomico River	0.14	0.32	0.05	0.17	Y	Y	Y	Y	1	19
Choptank River Upper	0.15	0.22	0.11	0.16	Y	Y	Y	Y	1	20
Little Conococheague Creek/ Licking Creek	0.14	0.34	0.00	0.16	Y	Y	Y	Y	1	21
Antietam Creek	0.32	0.15	0.00	0.16	Y	Y	Y	Y	1	22
Little Patuxent River	0.15	0.09	0.21	0.15	Y	Y	Y	Y	1	23
Potomac River Allegany County/ Sideling Hill Creek	0.35	0.04	0.00	0.13	Y	Y	Y	Y	1	24
Town Creek	0.15	0.19	0.00	0.11	Y	Y	Y	Y	1	25
Lower Susquehanna River/Octoraro Creek/Conowingo Dam Susquehanna River	0.19	0.66	0.78	0.54	Y	Y	Y		2	26
Pocomoke River Upper	0.42	0.69	0.49	0.53	Y	Y	Y		2	27
Northeast River/Furnace Bay	0.15	0.76	0.49	0.47	Y	Y	Y		2	28
Savage River	0.14	0.94	0.00	0.36	Y	Y	Y		2	29
Fifteenmile Creek	0.09	0.87	0.00	0.32	Y	Y	Y		2	30
South Branch Patapsco River	0.07	0.83	0.00	0.30	Y	Y	Y		2	31
Nanticoke River	0.14	0.33	0.37	0.28	Y	Y	Y		2	32
Mattawoman Creek	0.33	0.34	0.15	0.27	Y	Y	Y		2	33

Table 9-8. (Continued)

PSU NAME	Rarity	Biological Integrity	Migratory Fish	Average	BCU	GCN Stronghold	Listed Species Present	Listed Species Stronghold	Tier	Rank
Prettyboy Reservoir	0.10	0.64	0.00	0.25	Y	Y	Y		2	34
Middle Patuxent River	0.04	0.35	0.23	0.21	Y	Y	Y		2	35
Patuxent River Upper	0.30	0.00	0.32	0.21	Y	Y	Y		2	36
Little Gunpowder Falls	0.09	0.81	0.69	0.53	Y	Y			3	37
Bush River/Bynum Run	0.05	0.45	0.25	0.25	Y	Y			3	38
Miles River/Wye River	0.06	0.43	0.25	0.25	Y	Y			3	39
Gilbert Swamp	0.04	0.23	0.36	0.21	Y	Y			3	40
Loch Raven Reservoir	0.14	0.44	0.01	0.20	Y	Y			3	41
Sassafras River/Stillpond-Fairlee	0.07	0.22	0.17	0.15	Y	Y			3	42
St. Mary's River	0.19	0.40	0.45	0.35	Y		Y		4	43
Port Tobacco River	0.11	0.58	0.16	0.28			Y		4	44
Patapsco River Lower North Branch	0.37	0.15	0.12	0.21	Y		Y		4	45
Potomac River Lower North Branch	0.21	0.39	0.00	0.20	Y		Y		4	46
Fishing Bay/Transquaking River	0.19	0.10	0.19	0.16			Y		4	47
Wills Creek	0.20	0.25	0.00	0.15	Y		Y		4	48
Pocomoke Sound/Tangier Sound/Big Annemessex River/Manokin River	0.09	0.20	0.14	0.14	Y		Y		4	49
Marshyhope Creek	0.13	0.13	0.12	0.13	Y		Y		4	50
Conewago Creek/Double Pipe Creek	0.16	0.21	0.00	0.12			Y		4	51
Conococheague Creek	0.17	0.15	0.00	0.11			Y		4	52
Pocomoke River Lower	0.11	0.05	0.02	0.06	Y		Y		4	53
Eastern Bay/Kent Narrows/Lower Chester River/Langford Creek/Kent Island Bay	0.06	0.69	0.86	0.53	Y				5	54
Potomac Lower Tidal/ Potomac Middle Tidal	0.44	0.58	0.12	0.38	Y				5	55
Lower Elk River/Bohemia River/Upper Elk River/Back Creek/Little Elk Creek/Big Elk Creek/Christina River	0.13	0.26	0.49	0.29	Y				5	56
Chester River Middle	0.08	0.52	0.23	0.28	Y				5	57
Anacostia River	0.16	0.30	0.33	0.26	Y				5	58
Little Youghiogheny River/ Deep Creek Lake	0.25	0.25	0.00	0.17	Y				5	59
Bodkin Creek/Baltimore Harbor	0.04	0.21	0.17	0.14	Y				5	60
Honga River/Little Choptank River/ Choptank River Lower	0.12	0.21	0.07	0.13	Y				5	61
Potomac River Upper North Branch	0.12	0.20	0.00	0.11	Y				5	62
South River/West River	0.05	0.11	0.10	0.09	Y				5	63
Assawoman Bay/Isle of Wight Bay/ Sinepuxent Bay/Newport Bay/ Chincoteague Bay	0.02	0.00	0.19	0.07	Y				5	64

Table 9-8. (Continued)

PSU NAME	Rarity	Biological Integrity	Migratory Fish	Average	BCU	GCN Stronghold	Listed Species Present	Listed Species Stronghold	Tier	Rank
Liberty Reservoir	0.13	1.00	0.00	0.38						65
Winters Run Lower /Atkisson Reservoir	0.04	0.62	0.36	0.34						66
Magothy River/Severn River	0.08	0.26	0.58	0.31						67
Jones Falls	0.10	0.73	0.01	0.28						68
Aberdeen Proving Ground/Swan Creek	0.07	0.25	0.46	0.26						69
Monocacy River Lower	0.33	0.27	0.00	0.20						70
Wicomico River Lower /Monie Bay/ Wicomico Creek/Wicomico River Head	0.14	0.33	0.11	0.19						71
Brighton Dam	0.07	0.48	0.00	0.18						72
Rock Creek/Cabin John Creek	0.14	0.28	0.13	0.18						73
Evitts Creek	0.06	0.36	0.00	0.14						74
Gunpowder River/Lower Gunpowder Falls/Bird River/Middle River-Browns	0.07	0.11	0.24	0.14						75
Gwynns Falls	0.03	0.20	0.17	0.13						76
Seneca Creek	0.07	0.31	0.00	0.13						77
Patuxent River Lower	0.13	0.17	0.07	0.13						78
Patuxent River Middle	0.08	0.21	0.06	0.12						79
Back River	0.01	0.00	0.32	0.11						80
West Chesapeake Bay	0.01	0.14	0.14	0.10						81
Potomac River Frederick County	0.18	0.05	0.00	0.08						82
Georges Creek	0.06	0.16	0.00	0.07						83
Catoctin Creek	0.07	0.04	0.00	0.04						84

genera found in MBSS samples was used, 82 of the 84 watersheds in Maryland would be included.

To provide counties and other local jurisdictions with the information described above in a visual format, maps were prepared which show the relative ranking of each watershed within each county. On the same maps, specific reaches that rated high for biological intactness or had state-listed fishes, freshwater mussels, or stream herpetofauna present were also highlighted. This information is contained in: 2000-2004 Maryland Biological Stream Survey Volume 8: County Results (http://www/dnr/Maryland.gov/streams/pubs/ea05-n_biodiv.pdf).

The ranking method used here is a significant extension of a previous freshwater biodiversity hotspots project for Maryland fishes (Southerland et al. 1998). About 2.5 fold more MBSS data were used, and additional records of rare species not collected as part of the core MBSS were included in the mapping and analyses. In addition, metrics were weighted by stream miles where appropriate so that larger watersheds would not automatically tend to rank higher than small ones. Fish and benthic macroinvertebrate IBIs and observed vs. expected occurrences were substituted for species richness to account for the fact that some habitats have naturally low diversity. In addition, special focus was placed on watershed strongholds for state-listed and other GCN species, and the system of tiers also included the concept of including the minimum number of watersheds necessary to conserve all known native fishes, mussels, and stream herpetofauna. And finally, rankings within tiers incorporated rarity as well as use by migratory fishes, in acknowledgement of the fact that there is an inextricable link between estuarine and non-tidal waters in nearly all of Maryland.

9.8 NON-NATIVE STREAM AND RIVERINE ANIMAL SPECIES

The presence of non-native species in a freshwater ecosystem can have significant impacts on native biota, either directly through competition or predation, or indirectly via disease introduction or other mechanism. Once introduced, non-native species are usually impossible to eradicate and can have catastrophic consequences on native species. Because of these characteristics, the MBSS is tracking the distribution and abundance of non-native species. This chapter summarizes information from the MBSS about non-native stream and riverine animal species in Maryland. The reader should note that non-native plants are also important to freshwater biodiversity; terrestrial plants are addressed in Volume 10 of this report (http://www/dnr/Maryland.gov/streams/pubs/ea05-n_biodiv.pdf).

It is clear that a number of non-native freshwater species currently in Maryland have been documented to have an adverse impact on native freshwater biota. While specific studies of such impacts have not been done in Maryland, the weight of scientific evidence suggests that impacts are occurring in Maryland streams. With each additional species introduced, the risk of permanent, adverse ecological change is increased, including the possibility of introducing diseases that will affect native biota.

NORTHERN SNAKEHEAD IN MARYLAND

Of special recent interest is the discovery of northern snakehead in several locations in Maryland. In 2002, this species was discovered to have reproduced in a small pond in Crofton, Maryland. Ultimately this population was removed by use of a piscicide and does not appear to have spread into the adjacent Patuxent River network. Northern snakehead was also discovered and subsequently killed in a small pond in Montgomery County in 2004. Subsequent to that discovery, northern snakehead were discovered in the tidal freshwater portion of the Potomac River south of Washington DC. Both adults and young-of-year were represented among the 18 individuals collected by electrofishing in the tidal Potomac, indicating the possibility that this species has become established in Maryland and may spread into non-tidal waters. Although the ultimate predicted impact on on native and established non-native fishes in Maryland cannot be established, the fact that this species is a large, fast growing piscivore raises the possibility that significant changes in fish assemblages could occur.

9.8.1 Fishes

Sixteen out of a total of 26 non-native fish species known or thought to be extant in Maryland were collected during the 2000-2004 MBSS (Table 9-9). Most of the species not collected by MBSS are primarily reservoir species and are not regularly found in wadable non-tidal streams. Within drainage basins, new non-native occurrences for the MBSS were documented in the Elk (goldfish, fathead minnow, black crappie, and green sunfish), Bush (fathead minnow), Middle Potomac (goldfish), Gunpowder (goldfish), Patapsco (channel catfish), and Chester (common carp).

The total abundance of non-native fishes in Maryland streams during 2000-2004 was approximately 2.7 million, and the mean density was 296 fishes per stream During this time period, 36% of stream miles contained non-native fish species, and there were no major differences between river basins (Figure 9-53).

During 2001-2003, DNR Fisheries stocked approximately 5.4 million non-native fishes, or about 1.8 million fishes per year to provide recreational fishing opportunities or enhance the forage base for gamefish (Rivers 2005, pers. comm.). Nine different species were stocked, with life history stages ranging from adult to fry. In addition,

Table 9-9. Non-native freshwater fish species known or thought to be extant in Maryland, 2000-2004 (excluding species native to only a portion of Maryland)			
Species	**Status**	**Habitat & Extent**	**Impacts to Native Species**
Brown trout	> 50,000 stocked annually by DNR; numerous reproducing populations exist	Widely distributed in cool and coldwater habitats	Well documented impacts to brook trout; possible impacts to non-game fishes; possible disease introduction
Rainbow trout	> 500,000 stocked annually by DNR; only two reproducing populations known to exist (Hoyes Run and Sang Run)	Widely distributed in cool and coldwater habitats; put and take stocking in Coastal Plain areas as well	Well documented impacts to brook trout; possible impacts to non-game fishes; possible disease introduction
Cutthroat trout	Periodically stocked by DNR; only two reproducing populations known to exist (Jennings Randolf tailrace and Murley Run)	Mostly restricted to N. Br. Potomac River	Possible impacts to non-game fishes; possible disease introduction
Lake trout	Last stocked in 1986, few reported caught in recent years	Stocked in Jennings Randolph Reservoir; not reported from outside the impoundment	None documented
Channel catfish	Reproducing populations known from most major Bay tributaries.	Widely distributed in impoundments, larger rivers, oligohaline water	Possible negative impact to white catfish
Blue catfish	Reproducing population in the tidal Potomac River	Appears to prefer tidal oligohaline water	None documented
Flathead catfish	Known from the Susquehanna River in Pennsylvania and collected in the Potomac River in Maryland	Large river and impoundment species	None documented
Northern pike	Reproducing population known from Deep Creek Lake; also stocked in other impoundments	Primarily impoundments; spawns in flooded wetlands and inlet streams	Predation likely on GCN species that occupy same habitat
Tiger muskie	About 25,000 stocked annually by DNR, including Potomac River; hybrids are sterile	Large river and impoundment species	Predation likely on GCN species that occupy same habitat; potential disease introduction
Fathead minnow	Common bait fish species, stocked as forage by DNR; reproducing populations in some streams	Small-medium streams	None documented; may supplant native species in highly disturbed habitats; possible disease introduction
Goldfish	Sold as bait, also commonly released as pets; reproduce in ponds, reservoirs, and larger streams/rivers	Slow water habitat	None documented; possible disease introduction
Common carp	Introduced in 1870s; widespread reproducing populations	Slow water habitat in larger streams, rivers and impoundments	None documented
Grass carp	Sold as SAV control for golf course ponds, etc; likely in scattered ponds throughout the state	Slow water habitat in larger streams, rivers, and impoundments	None documented but pose significant threat to SAV; possible disease introduction from illegal shipments
Northern snakehead	Released into Potomac River and Crofton Ponds from pet trade, food trade, and/or religious purposes; possible reproducing population in tidal Potomac	Slow water habitat in larger streams, rivers, and impoundments	Possible predation- diets in FL consist of > 50% crayfish; possible disease introduction from illegal stocking
Banded darter	Introduced into Susquehanna River; reproducing populations in MD; apparently declined in last several decades	Larger streams	Hybridization with native darters
Rainbow darter	Likely introduced into MD portion of Potomac drainage; distribution expanding	Run habitat in larger streams and rivers	None documented
Walleye	About 800,000 stocked annually by DNR, including Potomac River	Larger streams, rivers, and impoundments	None documented, but predation on native rare cyprinids likely; possible disease introduction
Largemouth bass	Introduced to MD in 1870s; now statewide reproducing populations	Slow water habitat in larger streams, rivers, ponds, and larger impoundments	Likely impacts to smaller non-game species, including GCN species

Table 9-9. (Continued)			
Species	**Status**	**Habitat & Extent**	**Impacts to Native Species**
Smallmouth bass	Introduced to Atlantic slope; widespread reproducing populations in non-Coastal Plain	Medium and larger streams, rivers, and impoundments with coolwater habitat	Likely impacts to smaller non-game species, including GCN species
Bluegill	Introduced to Atlantic slope; widespread reproducing populations throughout MD	Slow water habitat in larger streams, rivers, ponds and larger impoundments	Likely impacts to smaller non-game species, including GCN species
Rock bass	Introduced to Atlantic slope; widespread reproducing populations throughout non-Coastal Plain	Rocky habitat in streams, rivers, and larger impoundments	Likely impacts to smaller non-game species, including GCN species
Green sunfish	Introduced to Atlantic slope; reproducing populations throughout non-Coastal Plain	Slow water habitat in streams, rivers, ponds, and larger impoundments	Likely impacts to smaller non-game species, including GCN species
Longear sunfish	Introduced to Potomac River	Slow water habitat in larger streams, rivers	None documented
Black crappie	Introduced to Atlantic slope; widespread reproducing populations throughout MD	Slow water habitat in larger streams, rivers, ponds, and larger impoundments	Likely impacts to smaller non-game species, including GCN species
White crappie	Introduced to Atlantic slope; widespread reproducing populations throughout MD	Slow water habitat in larger streams, rivers, ponds, and larger impoundments	Likely impacts to smaller non-game species, including GCN species
Redear sunfish	Introduced via pond stocking	Slow water habitat in larger streams, rivers, ponds, and larger impoundments	Potential impacts to smaller non-game species, including GCN species

anglers released an unknown number of non-native fishes and crayfishes after completing their fishing for the day. In 2004, fathead minnow and cutthroat trout were also stocked, bringing the total number of non-native fish species introduced in the past five years to 11.

Diseases confirmed at one or more coldwater hatchery facilities or their receiving streams during 2000-2004 included the parasite *Ichthyophthirius multifilus* (Ich), bacterial gill disease, Columnaris, and whirling disease (parasite *Myxobolus cerebralis*) (Rivers 2005, pers. comm.). The number of types of disease introduced from bait shops is unknown, as no monitoring for diseases is required or performed. It should be noted that no hatchery-associated fish diseases have been determined to have a negative effect on native biota in Maryland. However, no monitoring of native species for this purpose is conducted.

Five of the six most abundant non-native fish species collected by the MBSS during 2000-2004 were members of the sunfish family. The most abundant was bluegill, followed by green sunfish, smallmouth bass, brown troutlargemouth bass, and rock bass (Table 9-2). One species, rainbow darter, has recently expanded its range in Maryland, and now occurs in four major basins (Table 9-1). Of all non-native species found in Maryland, the most extensive documentation of negative effects is for brown trout (Fausch and White 1981; Waters 1983; Lasenby and Kerr. 2001). MBSS data collected to date support these findings: brook trout were rarely collected in high numbers at sites where brown trout were even moderately abundant.

9.8.2 Bivalves

Asiatic clam (*Corbicula fluminea*), a bivalve introduced to the Potomac River around 1977 (Phelps 1994), has apparently expanded its distribution in Maryland. Between 1995-1997 and 2000-2004, Asiatic clams expanded from 13 to 16 of 18 river basins (Figure 9-54). The only remaining basins where Asiatic clam has not been documented by the MBSS include the Lower Potomac and Ocean Coastal basins. Asiatic clams compete with native unionid mussels and sphaerid clams and are considered deleterious to them (Fofonoff 1998), and illegal harvest of this species (observed several times in the Potomac River by P. Kazyak), likely disrupts or destroys native bivalves.

An additional non-native bivalve that is not yet believed to be in Maryland waters but poses a serious threat to freshwater biodiversity is zebra mussel (*Dreissena polymorpha*). This species now occurs in the upper Susquehanna River drainage in New York State, in a Northern Virginia quarry within the Potomac drainage, and in several locations within easy driving distance of western Maryland. In other areas of the U.S., zebra mussels have out-competed native unionids and caused fundamental shifts in trophic structure (Marsden 1992; Ludyanskiy et al. 1993; Karatayev et al. 2002).

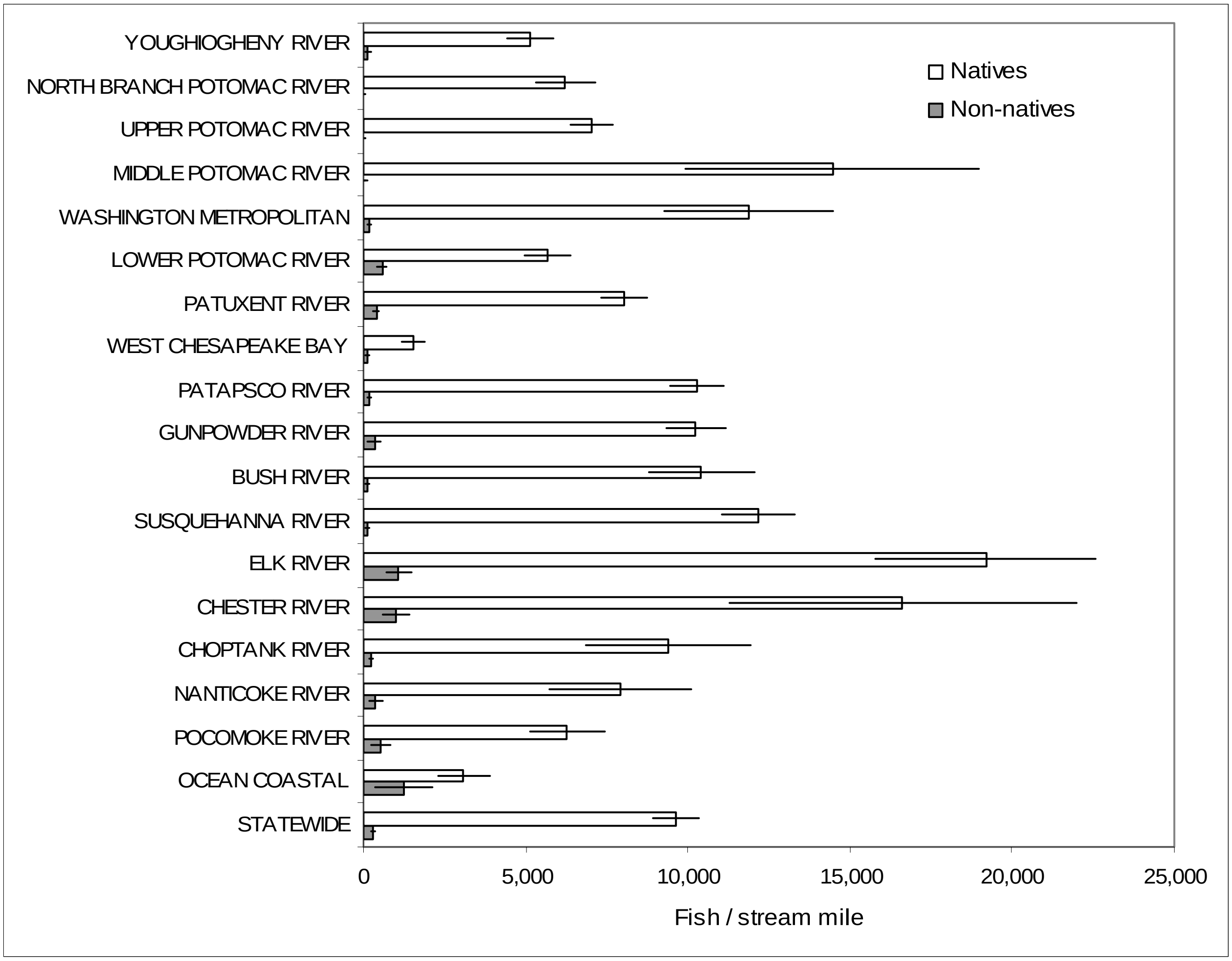


Figure 9-53. Density bar graphs for native and non-native fishes, by basin, based on data from the 1995-2004 MBSS

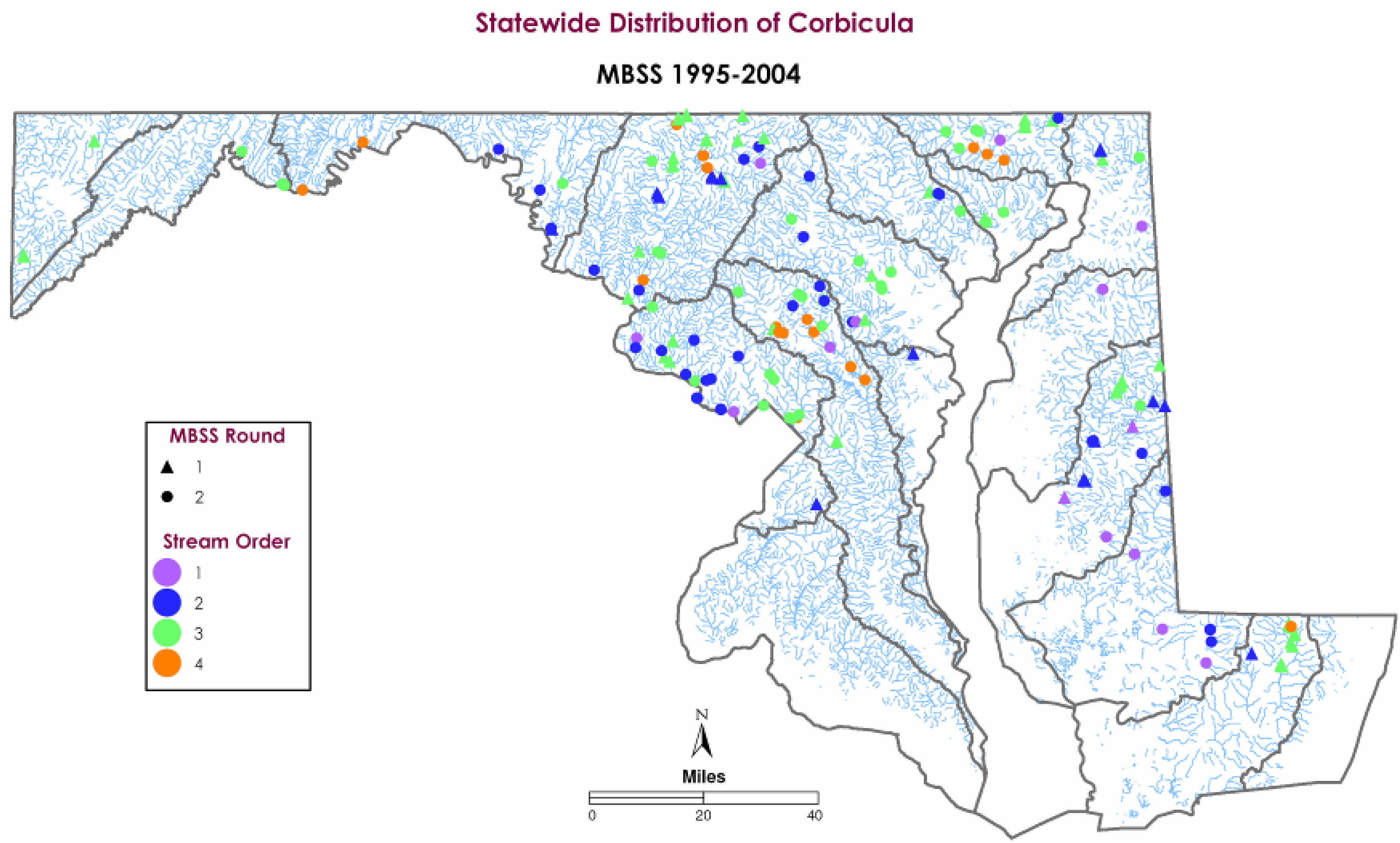


Figure 9-54. Distribution of the Asiatic clam (*Corbicula fluminea*) in Maryland, based on 1995-2004 MBSS data

9.8.3 Crayfishes

Two non-native crayfishes, *Orconectes virilis* and *Procambarus clarkii* have been reported from Maryland, (Meredith and Schwartz 1960; McGregor 1999). Although likely introduced, there are no confirmed records of *O. rusticus* in Maryland. During the 1996-1997 MBSS, crayfishes were collected in 13 major river basins, including one non-native species, *O. virilis*.

Based on the historic distribution described by McGregor (1999), *Orconectes virilis* is expanding its range in Maryland. First documented from the Patapsco River basin around 1960 (Meredith and Schwartz 1960), this species was collected in two-thirds of the basins sampled during the 1996-97 MBSS (Figure 9-55). This expansion is potentially important because *O. virilis* is thought to have displaced the native *O. limosus* and *C. bartonii* from the mainstem Patapsco River and restricted their distribution to small headwater tributaries (Schwartz et al. 1963). The limited occurrence of *O. limosus* where *O. virilis* now occurs (see Figure 9-38) supports the hypothesis that *O. virilis* is displacing native crayfishes.

MBSS collections of *P. acutus* in Carroll, Harford, and Anne Arundel counties represent the first known records of this native species at these locations (Figure 9-56). These new occurrences of *P. acutus* in Central Maryland could be evidence of the transfer of this native species through bait buckets. The transfer of native species into new areas could also cause potential problems in aquatic ecosystems.

A reduction in abundance or outright loss of native crayfish species following the introduction of non-native species has been observed in many areas of the country (Capelli 1982; Butler and Stein 1985; Olsen et al. 1991). Non-native crayfishes also have repercussions for other components of stream ecosystems, having been blamed for dramatic changes in aquatic macrophyte, macroinvertebrate, and herpetofaunal communities throughout North America (Chambers et al. 1990; Fernandez and Rosen 1996; Rosen and Fernandez 1996).

9.9 MAINTAINING STREAM AND RIVERINE BIODIVERSITY IN MARYLAND

A number of key findings with management implications were identified during the biodiversity analyses conducted for this volume. This chapter summarizes those findings and presents management recommendations and challenges for stream and riverine biodiversity conservation in Maryland.

9.9.1 Key Findings

9.9.1.1 Establishment of a Stream and Riverine Biodiversity Baseline

Data from the more than 2,500 quantitative MBSS sites and other data included in this volume provide one of the most detailed, broad-scale accounts of freshwater biodiversity and associated habitats available in the United States. Using these data, and numerous GIS layers that help quantify environmental stressors, we have identified threats and conservation actions that can be used to protect stream and riverine biodiversity. The quantitative information on fish assemblages provide a rigorous means to assess and track future changes, and the information on stream herpetofauna and benthic macroinvertebrates provides a baseline database to track changes in taxa that are currently common. MBSS data for crayfishes and freshwater mussels are incomplete, but still valuable in helping to track future changes in species distribution and relative rarity.

Fishes

The total number of freshwater fishes in Maryland streams is around 91 million. Of the 77 freshwater fish species native to some part of Maryland and commonly found in streams and rivers, 19 are presently found in very low numbers or are contained in a very small geographic area. These fish species are at risk of extirpation due to localized catastrophic events. There are at least 16 distinct fish assemblage types in Maryland. These assemblages are primarily defined by location within the State, stream size, watershed elevation, pH, and dissolved organic carbon levels. However, this estimate of fish assemblage types was based on the distribution and abundance of common species. Expanding this analysis to include rare species may result in a more complete depiction of assemblage diversity in Maryland, which may aid future development of an assemblage-based conservation plan for Maryland fishes.

A number of common species are isolated in watersheds so that their ability to colonize other areas is severely restricted. To preserve ecological function in Maryland streams and a variety of beneficial goods and services, even common species should be considered as part of an overall biodiversity management approach. Certain watersheds are considered Evolutionarily Significant Units for Maryland fishes; extra recognition at the regional level for these watersheds may be appropriate. Another consideration, in light of the intimate connection between the Chesapeake Bay and Coastal Bays and their

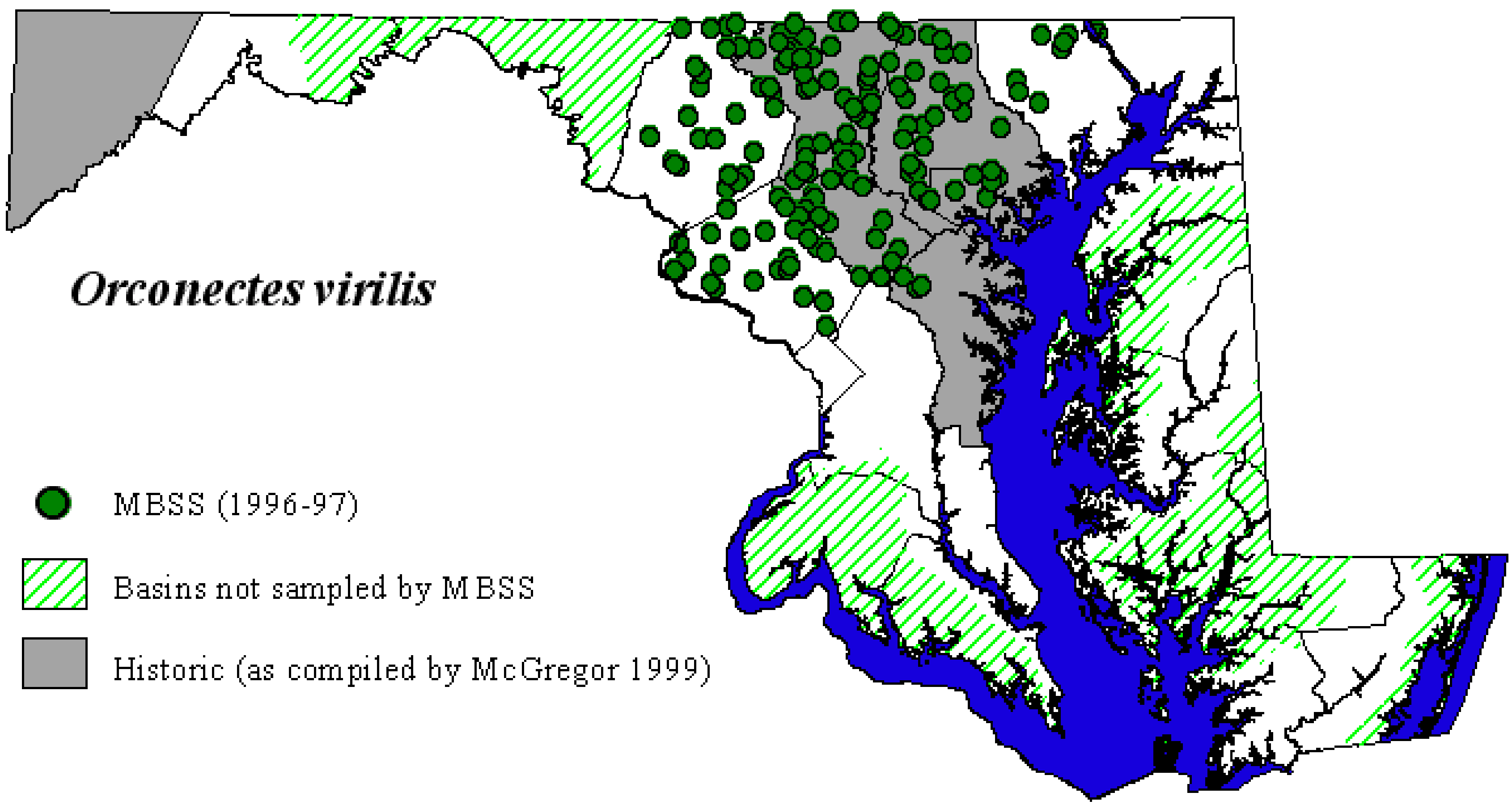


Figure 9-55. Historic and current distribution of the non-native crayfish Orconectes virilis in Maryland based on historic distribution reported in McGregor (1999) and the 1996-1997 MBSS

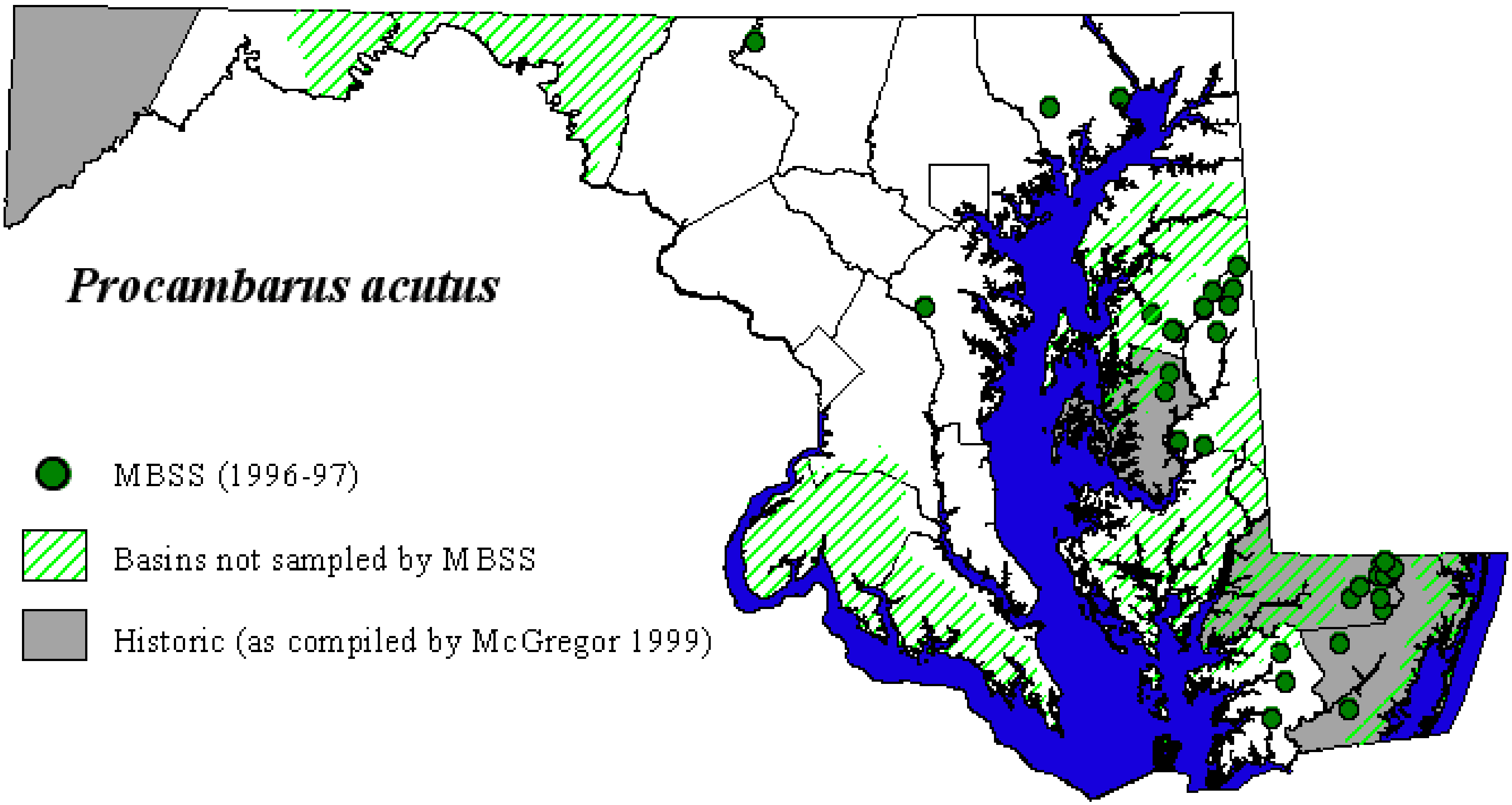


Figure 9-56. Historic and current distribution of the native crayfish *Procambarus acutus* in Maryland based on historic distribution reported in McGregor (1999) and the 1996-1997 MBSS

tributaries, is migratory fishes. Because migratory fishes are a key functional element to both streams and estuarine waters, extra consideration should be given to addressing migration barriers in an overall protection and restoration strategy.

Herpetofauna

It is clear that many stream and riverine herpetofauna are sensitive to a number of types of human disturbance measured by the MBSS. In addition, a growing body of literature indicates that other factors may also be playing an important role in population declines. Based on historical information, the ranges of many species have been drastically reduced in Maryland, and the need for action appears to be urgent.

Benthic Macroinvertebrates

The diversity of benthic macroinvertebrates in Maryland streams and rivers is high, and analyses based on genus level data indicated that a large number of genera are highly rare in lotic habitats. However, the actual distributions of rare taxa may be underestimated because of the relatively small, 100-organism subsample used for each site. Conversely, if data were available by species, chances are that an even higher degree of rarity would be apparent. If conservation of all benthic macroinvertebrates becomes a management goal, protecttion or restoration of nearly every watershed in Maryland will be necessary.

9.9.1.2 Biodiversity Information Gaps

Although stream and riverine biodiversity information from the MBSS is extensive, there are significant knowledge gaps and monitoring needs. For example, understanding life history requirements of aquatic species (e.g. migration habits and the degree of habitat connectivity needed), and species-specific stressors are critical gaps for many species. In addition, genetic information is available for only a few freshwater species in Maryland. Genetics information is needed to help identify distinct populations as well as specific actions to ensure that all native species persist over time.

The assessment of fishes, stream herpetofauna, and benthic macroinvertebrate fauna in this volume established a clear need for additional distribution information as well. In general, a status assessment should be conducted for all stream reaches where state-listed stream and riverine fauna have been documented. In addition, continuation of random MBSS sampling will eventually fill in areas that have not been surveyed for biodiversity, while providing statistically rigorous information on water quality. This sampling should include crayfishes, freshwater mussels, benthic macroinvertebrates to species, and more intensive collection of stream herpetofauna data. Sampling in other important habitat types should also be considered. Historically undersampled habitats such as springs, ephemeral streams and vernal pools are of particular interest. Additional sampling in larger streams and rivers is also necessary to fully characterize biota in those habitats.

9.9.1.3 Stressors to Stream and Riverine Biodiversity

The fish, benthic macroinvertebrates, and stream herpetofauna information presented in this volume clearly demonstrates that freshwater biota are sensitive to a wide array of stressors, including imperviousness, acid deposition, acid mine drainage, loss of riparian buffers, and physical habitat degradation. Given the statewide or regional scope of many of these threats, continuation or expansion of these threats will likely have a profound negative effect on stream and riverine biodiversity in the future. It is clear that habitat alteration and loss, with concomitant loss of species, has occurred statewide and continues to occur, in spite of existing laws and regulations (such as the goal of the federal Clean Water Act to restore and maintain the physical, chemical and biological integrity of the nations' waters). Given that freshwater organisms have a limited capacity to absorb the effects of human disturbance, prompt intervention may be needed to maintain viable populations of some species. For highly imperiled species such as stripeback darter, preparation and immediate implementation of recovery plans may be the most appropriate way to retain their presence for future generations of Marylanders. In some cases, historical degradation may have resolved itself, but restoration of biodiversity will require reintroductions to reestablish balanced indigenous communities and/or extend species distributions and reduce the chance of catastrophic loss. Stonecat is an example of a species for which translocation to the recovered Youghiogheny River mainstem should be considered.

Non-native species represent a growing and important threat to Maryland's freshwater biodiversity. Based on historical data and survey work done by the MBSS, several non-native species of crayfishes appear to be expanding in Maryland. The expansion of introduced crayfishes and the concomitant loss of two native crayfishes from the same area strongly support the possibility of competitive or predatory exclusion. Available literature also indicates that introduced crayfishes may play an important role in the elimination of freshwater mussels via predation on juveniles. The spread of non-native crayfishes to more watersheds in Maryland could have potentially disastrous results for the remaining freshwater mussels in the State. A similar expansion of the Asiatic clam in Maryland waters may be having the same effect on native mussels.

There is potential for newly introduced species such as northern snakehead to reduce or eliminate native fish populations. Fish species that continue to be stocked for recreational fishing pose an ongoing threat to biodiversity. There is a well-established body of published literature on the negative effects of brown trout on brook trout, Maryland's only native salmonid and a species designated as being in Greatest Conservation Need. Further, the presence of few brook trout when brown trout were present at MBSS sites supports the concept that brown trout can eliminate or greatly reduce brook trout populations when they are introduced. Finally, there is an unknown risk of spreading non-native diseases to native biota via the culture and stocking of hatchery fishes. A decade ago, the risk of transferring hatchery diseases to wild fishes was thought to be very minimal, but the decimation of native rainbow trout in many areas of the western U.S. by whirling disease suggests that the potential for disease impacts should be considered as part of biodiversity management.

Indirect effects of introduced species may also be significant. For example, the presence of woolly adelgid, a plant parasite, and other plant diseases such as leaf blight could alter species composition and shading along coldwater streams. Similarly, expansion of terrestrial plants such as tearthumb, garlic mustard, and multiflora rose, is likely to reduce regeneration of new trees, ultimately altering a number of stream characteristics. In the western US, alien riparian plants have been shown to be a major potential threat to stream ecosystems (Hughes 2005, personal communication).

Although non-native species are found extensively in and along Maryland streams and rivers, stressors such as impervious surface and acid mine drainage have an even larger influence on biodiversity in the watersheds where they occur. Additionally, physical habitat degradation, flow alterations, and temperature modifications from land use disturbance all have an important influence on the variety of life in streams and the way in which energy is processed.

9.9.1.4 What to Protect?

It is clear from the results of this volume that if preservation of the economic value of goods and services arising from Maryland's stream and riverine biodiversity network is considered a management priority, then restoration and protection efforts need to extend well beyond establishing and maintaining small reserves of the best remaining habitats. Using measures of biotic integrity and strict criteria for land use and water quality, most of the "best" sites in Maryland occur in western Maryland. However, because biodiversity is important to preserve at a statewide scale, streams throughout the State need to be protected and restored where possible. Within this volume, Maryland now has a template for including consideration of stream and riverine biodiversity in water-shed evaluations and the implementation of watershed-based management plans.

In comparison to the estuarine portion of the Chesapeake Bay watershed, the streams and non-tidal rivers contain far more rare and imperiled fishes (Figure 9-57). Potential reasons for this include the relative isolation of streams and rivers and the greater ability of estuarine fishes to seek refuge. To effectively manage the Maryland portion of Chesapeake Bay as an ecosystem, it may be

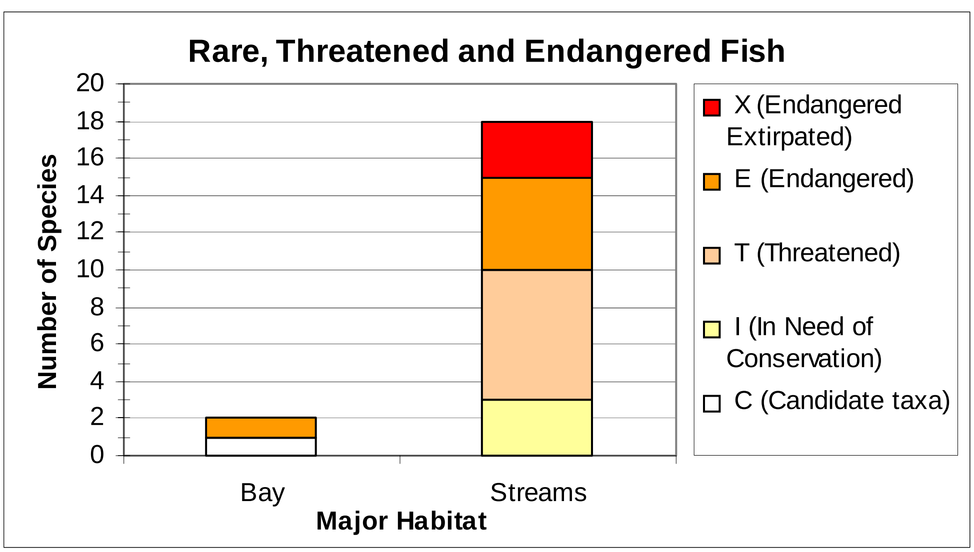


Figure 9-57. State and federal listed rare fish species in Chesapeake Bay and in non-tidal streams and rivers of Maryland (source: Nongame and Endangered Species Conservation Act (Annotated Code of Maryland 10-2A-01)

appropriate to target activities in waters inhabited by rare or imperiled species so as to benefit both freshwater biodiversity and Bay health.

TIME BOMBS

For the purposes of aquatic biodiversity management, a time bomb is a highly detrimental condition that is likely to occur in a watershed. Examples of time bombs include, periodic leaks/ discharges of raw sewage, flushes of toxic levels of urban or agricultural contaminants during storms, or significant increases in imperviousness in a watershed. The most probable outcome of this condition would be a severe reduction (including the possibility of elimination) in stream and riverine biodiversity.

The results of the watershed ranking exercise demonstrate that there are extensive areas of biodiversity importance in every county and Baltimore City. A total of 25 watersheds were strongholds for state-listed stream and riverine species, and an additional 11 watersheds were strongholds for non-listed GCN species and also contained one or more state-listed taxa. Six watersheds contained at least one state-listed species but were not strongholds for those species. An additional 14 watersheds were necessary to capture the full compliment of fishes, stream herpetofauna, freshwater mussels, and rare, sensitive benthic macroinvertebrates found in Maryland. It is also noteworthy that every watershed in Maryland contained at least one GCN species, and that conservation of 82 of 84 watersheds will be necessary to conserve all presently known benthic macroinvertebrate stream genera. Again, if conservation of freshwater biodiversity for future generations of Marylanders is an important resource management concern, some increase in habitat protection will be necessary for all watersheds, with possible increased focus on those areas that are still strongholds for rare species.In the future, a formal GAP analysis following the USGS (2005) protocols may be warranted to further our understanding of which species and habitats are least protected by current land and water management programs

Because of the dominance of privately-owned land in the State and the fact that many of the highest ranked areas in the State occur on non-public land, it is apparent that habitat protection and restoration on public lands alone will be insufficient to protect stream and riverine biodiversity in Maryland. At the other end of the spectrum, some watersheds in Maryland are so highly disturbed and have such frequent occurrence of 'time bombs' that until the most serious threats are abated, management for human health may be a more appropriate strategy for these watersheds than management for biodiversity.

Conservation of biodiversity has historically focused on species poised on the brink of extinction, with effort placed on preserving the last remnant populations of these species. Often, this approach is applied only at times of extreme crisis, when populations have reached a critical minimum size. This may occur after the loss of critical habitats, communities, and ecological functions that are necessary for the persistence of the species of interest. An accurate characterization of this reactive approach to biodiversity conservation is "too little, too late." More recently, biodiversity conservation efforts have become proactive and focused on protection of communities and larger ecological scales. This conservation approach is advantageous because the preservation of an ecosystem or community serves to protect each individual species within that community. Community-level conservation is a cost-effective approach, preserving biodiversity more effectively and efficiently (Angermeier and Winston 1999).

9.9.2 Threats and Possible Biodiversity Conservation Actions

It is clear that threats to stream and riverine biodiversity in Maryland are highly diverse and often interconnected. As a result, interdisciplinary assessment and management are keys to reducing or eliminating threats. The intimate relationship between streams and their watersheds also means that management actions concerning stream and riverine biodiversity should include terrestrial habitats. However, because stream biota are linearly distributed and dependent on their upstream catchments, even terrestrial actions should be considered within a watershed context.

To assist in identifying appropriate actions for managing freshwater biodiversity in Maryland watersheds, a list of threats to freshwater biodiversity was prepared, by watershed (Appendix D). A focal point in listing of threats was the degree to which they were directly linked to management actions. For example, several components of urban effects were identified, because specific management actions would potentially address those issues. The extent of each threat was estimated for each watershed, and trends, severity, persistence, and reversibility were rated for each threat. These ratings were combined to derive both a restoration/rehabilitation ranking and a need for prevention/expansion for each threat. It should be emphasized that these ratings provide a relative importance for each threat in each watershed, but do not imply an absolute priority to be followed in prescribing conservation actions.

Additionally, a list of possible conservation actions was identified, along with a compilation of what primary threats were addressed by each (Table 9-10). Each of the listed activities should help improve or maintain water

Table 9-10. Conservation actions and the threats they are intended to address, along with potential effectiveness			
Type	**Comments**	**Threats Addressed (using #s from PSU threats)**	**Potential Effectiveness**
Land Preservation			
Includes easements and agreements, fee simple purchase		Fragmentation, degradation and loss of critical habitat	High
Agricultural Best Management Practices			
Grassed swales, terraces, contours		Pesticide/herbicide application Sedimentation Nutrient enrichment	Moderate
Windbreaks, residue management		Removal or degradation of riparian buffers Pesticide/herbicide application Sedimentation	Moderate
Pest management		Pesticide/herbicide application	Moderate
Nutrient (fertilizer) management		Nutrient enrichment	High
Livestock exclusion, off-stream watering, rotational grazing		Livestock and grazing impacts Lack of or degradation of riparian buffers	High
Waste storage		Livestock and grazing practices Nutrient enrichment	Moderate
Conservation tillage		Sedimentation	Moderate
LID farm building retrofits		Runoff Sedimentation Nutrient enrichment	Moderate to High
Wetland restoration		Degradation of seepage wetlands Stream and groundwater withdrawal	Moderate
Regulatory			
NPDES permit alteration		Chemical and hydrologic change due to urban land use and impervious surface	Moderate
TMDL implementation		Nutrient enrichment Chemical and hydrologic change due to urban land use and impervious surface Sedimentation	Varies
Water withdrawal permitting		Stream and groundwater withdrawal	Varies
Use Classification		Recreational use	Moderate
Atmospheric controls		Atmospheric deposition	High
Stream Channel Rehabilitation		Stream blockages Stream channelization	Moderate
Riparian Buffer Planting	Success is invasives - dependent	Lack of and degradation of riparian buffers Timber harvest	Varies
AMD Treatment		Acid mine drainage Atmospheric deposition	Moderate
Invasive Spp Management	Plant or animal, aquatic or terrestrial	Non-native species	Varies

Table 9-10. (Continued)			
Type	**Comments**	**Threats Addressed (using #s from PSU threats)**	**Potential Effectiveness**
Urban			
Stormwater & LID controls/ retrofits		Chemical and hydrologic change due to urban land use and impervious surface	Varies
Repair/replace/ separate sewage lines			High
WWTP treatment upgrades	Primary effect is on larger streams low in the watershed		High
Urban education	Not effective unless reinforced	Recreational use	Low
Reduce/reuse/ recycle			High

quality, ultimately providing direct benefit to the GCN species within them as well as to overall freshwater biodiversity.

9.9.2.1 Funding and Implementation

Although a large number of potential funding sources are available to implement Conservation Actions in Maryland's watersheds, perhaps the greatest opportunity for protecting and enhancing stream and riverine GCN species and overall freshwater biodiversity is to link biodiversity efforts with Chesapeake Bay and Coastal Bays restoration efforts. Combined, these two programs include all of Maryland except the Youghiogheny basin in western Maryland. If freshwater protection and restoration priorities can be factored into geographic targeting and funding decisions, both estuarine and non-tidal biodiversity will likely benefit. An expanded focus on stream and riverine biodiversity in the Chesapeake Bay and Coastal Bays Programs would be a logical extension of the ecosystem and multi-species management approaches under development.

In addition, a number of counties, especially in central Maryland, have ongoing or planned stream and watershed rehabilitation activities. If counties can be convinced to factor GCN species benefits into their decision-making process, additional progress in protecting GCN species should result. In addition, the Maryland Department of Transportation is responsible for mitigating the effects of road construction; incorporation of GCN species protection and enhancement opportunities into transportation mitigation plans should result in additional direct benefits to GCN species.

Another opportunity for implementing GCN species protection and enhancement exists with the Maryland Department of the Environment (MDE). MDE is responsible for developing and implementing Total Maximum Daily Loads (TMDL) plans for impaired waters (as required under Section 303d of the Clean Water Act). Because many impaired waters also contain stream and riverine GCN species, incorporation of GCN species protection and enhancement activities into the TMDL process should directly benefit GCN species. Similar benefits may be achieved if GCN species conservation actions are incorporated into National Point Source Discharge Elimination (NPDES) permitting, Bureau of Mines mitigation/reclamation efforts, and Surface Water Appropriations Permit processing.

Some GCN species protection and enhancement activities, such as riparian buffer plantings, are suitable for implementation by volunteers. Therefore, recruitment of watershed groups and interested citizens to undertake specific actions in specific locales could further benefit GCN species.

9.9.2.2 An Approach to Management

Effective protection and restoration of stream and riverine biodiversity in Maryland will require development of a vision for the future. One such vision would be: *to ensure long-term viability of all native aquatic species and natural aquatic community types, within their natural ranges, with no net loss of ecosystem function and services.* Under this vision, biodiversity concerns would extend beyond a conserved network of remnant habitats containing rare species, and include conservation even in disturbed habitats. A justification for this approach is that the goods and services, such as water quality control for the Chesapeake Bay, provided by the more common species are also deserving of attention. In fact, the totalestimated value of economic and environmental benefits of biodiversity in Maryland is about $1.9 billion annually (Pimentel 1998). Marylanders seem to understand this value; PKF Consulting (1995) found in an attitude survey that 91% of Maryland citizens support leaving some parts of the environment in their natural condition forever. The concept of having natural areas close to home and work was also highly supported (77%). These results support the belief that humans have "biophilia", or an innate need for nature (*sensu* Wilson 1984). However, the economic justification for bio-diversity conservation is also significant, and would appear to justify pursuing quantitative conservation goals and using public resources as an investment in the future.

Assuming that how much stream and riverine biodiversity to conserve or restore is not the question, the next step to consider is how to effectively conserve, and, where necessary, restore stream and riverine biodiversity. It is important for Marylanders to recognize that there are no pristine or completely intact stream and riverine habitats; even totally forested areas in the Appalachian Plateau and Coastal Plain are subject to the effects of acid deposition and other wind-borne pollutants. The scarcity of high quality habitat and the fact that protection is far more cost-effective and efficient than restoration suggest that preservation should be a high priority in any biodiversity conservation strategy.

Nonetheless, restoration, often of a long-term nature, will be necessary to reestablish lost resources. The concept of ecological triage for restoration and rehabilitation efforts may be appropriate initially. Using this approach, work would center on the most critically 'ill' populations that have a good chance of recovery first, and so on, with less effort initially expended on populations unlikely to survive or that are in watersheds with known 'time bombs.' Over the long term, Doppelt et al. (1993) provide a strategy that may be appropriate for sustained management of stream and riverine biodiversity in Maryland. In their view, high quality areas should be secured and appropriate restoration work conducted. Then, work to establish corridors between high quality areas should be implemented. And finally, work on the most degraded areas should occur. In this way, stream and riverine biodiversity is most likely to be retained, and lessons learned from restoring higher quality areas can be applied to the more difficult and costly problems and areas.

EDUCATION AND STEWARDSHIP

Mapping and Monitoring Maryland Streams is a teacher professional development project initiated in 2005 to educate students about their streams using real world MBSS data and Geographic Information Systems (GIS). A goal of the project is to develop stewardship of streams and watersheds through locally relevant, hands-on lessons.

On a national basis, freshwater biota such as freshwater mussels, crayfish, amphibians and fishes are the groups most threatened with local extirpation or complete extinction. Given this fact, and the fact that within the Chesapeake Bay ecosystem the preponderance of imperiled aquatic species occurs not in the Bay, but in its tributary systems, it is important to focus management attention on stream and riverine biodiversity.

9.9.2.3 Challenges

A number of challenges to and opportunities for the conservation of freshwater biodiversity exist in Maryland. Importantly, protecting and restoring biodiversity involves not just science, but humans making decisions about what they intend to leave the next generation. Traditionally, decision making about the natural environment and its biodiversity has been based more on cultural traditions than on an inventory of what science says is important (Burch 1998). Because of this, education of a rapidly urbanizing citizenry is a defacto critical challenge to changing public perceptions about protection and restoration. A particular challenge will be to educate Marylanders about the cumulative effects their actions have on stream and riverine biodiversity, and to present alternatives that are palatable as well as meaningful. If a broad audience can be educated about the value of goods and services provided by freshwater biodiversity, and DNR's best estimates of what will be lost at projected rates of land use change, support for an active, ongoing restoration and protection program will be easier to affect.

Stream and riverine habitats pose a special challenge for classification and management, because both upstream, downstream, and watershed characteristics can override local instream conditions and cause the elimination of species. Further, interpretation of data must be done realizing that juxtaposition in a system and nearness to higher quality areas all influence biological community makeup. Because streams flow through watersheds that are primarily or sometimes wholly in private ownership, protection and restoration pose a special challenge, with stewardship and education the keys to success.

An additional challenge is the need to set explicit goals and concrete ways to measure progress, including establishment of population targets for each species of conservation interest. Population targets should, at a minimum, ensure species viability. A further need is to consider establishing specific goals of biological condition for individual watersheds, with biological reintroduction being a key element when appropriate.

A final challenge, and key opportunity, is that management efforts concerning Chesapeake Bay and Maryland's Coastal Bays have not explicitly incorporated stream and riverine biodiversity into planning and implementation. Doing so represents a significant way to aid in preservation of the most imperiled habitats in the State.

Ultimately, protecting and restoring stream and riverine biodiversity must involve not just science, but Marylanders making a conscious decision about how much nature to leave future generations. If changes in the current management of stream and riverine biodiversity are not made, the results are clear- many species and unique communities will disappear from the State, along with many habitats and natural processes. A coordinated, holistic approach that goes beyond treating isolated symptoms and steps normally taken for human health, recreation, and direct economic needs is necessary. To garner support for such an approach, there is a strong need to educate Marylanders about the value of stream and riverine biodiversity, the critical relationship of streams and rivers to bays, and the intimate tie-in between human activities and the resulting economic and ecological costs. It is our hope that this volume will provide relevant information for the development of a statewide, science based, blueprint to guide stream and riverine biodiversity conservation in Maryland.

For in the end, we will conserve only what we love. We will love only what we understand. We will understand only what we are taught.

Baba Dioum

9.10 LITERATURE CITED

Allan, J.D., and A.S. Flecker. 1993. Biodiversity conservation in running waters. Bioscience 43:32-43.

Angermeier, P.L., and M.R. Winston. 1999. Characterizing fish community diversity across Virginia landscapes: prerequisite for conservation. Ecological Applications 9:335-349.

Baker, B M. and R.P. Morgan II. 1991. Development of genetic inventories for Maryland game fish: brook trout. Final Report. State of Maryland Dept. of Natural Resources, Tidewater Administration, Annapolis, MD.

Biggins, R.G. and R.S. Butler. 2000. Bringing mussels back in the southeast. Endangered Species Bulletin 25(3):24-26.

Blockstein, D.E. 1992. An aquatic perspective on U.S. biodiversity policy. Fisheries 17:26-30.

Bogan, A.E., and T. Proch. 1997. Manual of the Freshwater Bivalves of Maryland. Chesapeake Bay and Watershed Programs, Monitoring and Non-Tidal Assessment. CBWP-MANTA, EAP-96-3.

Braun, D.P., L.B. Bach, K.A. Ciruna, and A.T. Warner. 2000. Watershed-scale abatement of threats to freshwater biodiversity: the Nature Conservancy's Freshwater Initiative. *In* Conference Proceedings, Watershed 2000, Vancouver, BC. Water Environment Federation.

Burch, W.R., Jr. 1998. The weight of time: constraints and opportunities in maintaining and restoring biodiversity of the Chesapeake Bay Region. *In:* G.D. Therres, ed., Conservation of Biological Diversity: A Key to the Restoration of the Chesapeake Bay Ecosystem and Beyond. Maryland Dept. Natural Resources, Annapolis, MD.

Burke, D., K. Kehoe, M. Herrmann, L. Davidson, and C. Towle. 2004 draft. Maryland coastal and estuarine land conservation plan. Prepared by Coastal Zone Management Division, Maryland Dept. Natural Resources, Annapolis, MD.

Burke, D., M. Bundy, F. Dawson, B. Hodges, J. Horan, W. Jenkins, R. Klauda, K. McCarthy, J. McKnight, T. Moore, J. Mullan, A. Norden. T. Saunders, and M. Slattery. 1996. Ecosystem-based management: recommendations of the Ecosystem Council. Maryland Dept. Natural Resources, Annapolis, MD.

Butler, M.J. and R.A. Stein. 1985. An analysis of mechanisms governing species displacement in crayfish. Oecologia 66:168-177.

Capelli, G.M. 1982. Displacement of northern Wisconsin crayfish by *Orconectes rusticus* (Girard). Limnol. Oceanog. 27:741-745.

Chambers, P.A., J.M. Hanson, J.M. Burke, and E.E. Prepas. 1990. The impact of the crayfish *Orconectes virilis* on aquatic macrophytes. Freshwater Biology 24:81-91.

Chapin, F.S. III, E.S. Zavaleta, V.T. Eviner, R.L. Naylor, P.M. Vitosek, H.L. Reynolds, D.U. Hooper, S. Lavorel, O.E. Sala, S.E. Hobbie, M. Mack, and S. Diaz. 2000. Consequences of changing biodiversity. Nature 405:234-242.

Costanza, R., R. d'Arge‡, R. de Groot, S. Farberk, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. van den Belt. 1997. The Value of the World's Ecosystem Services and Natural Capital. Nature 387:253-260.

Daily, G.C., and K. Ellison. 2002. The new economy of nature: the quest to make conservation profitable. Island Press, Washington, DC.

Danzmann, R.G., R.P. Morgan II, M. W. Jones, L. Bernatchez, and P. E. Ihssen. 1998. A major sextet of mitochondrial DNA phylogenetic assemblages extant in eastern North American brook charr (*Salvelinus fontinalis*): Distribution and post-glacial dispersal patterns. Can. J. Zool. 76:1300-1318.

DNR (Maryland Dept. Natural Resources). 1996. Lands Strategic Plan for Recreation and Conservation. Maryland Dept. Natural Resources, Annapolis, Maryland. (http://intranet/resourceplanning/lsplan.pdf)

DNR (Maryland Dept. Natural Resources). 2001. Conservation of biological diversity: a key to the restoration of the Chesapeake Bay ecosystem and beyond. G.D. Therres, ed. Maryland Dept. Natural Resources, Annapolis, MD, 1998.

DNR (Maryland Dept. Natural Resources). 2003a. Maryland's strategic forest lands assessment. Prepared by Watershed Services and Maryland Forest Service, Maryland Dept. Natural Resources, Annapolis, MD.

DNR (Maryland Dept. Natural Resources). 2003b. Rare, threatened, and endangered animals of Maryland. Maryland Dept. Natural Resources, Annapolis, MD.

DNR (Maryland Dept. Natural Resources). unpublished data. Fish Blockage Database. Maryland Department of Natural Resources Fisheries Service, Annapolis MD.

Doppelt, B., M. Scurlock, C. Frissell, and J.R. Karr. 1993. Entering the watershed: a new approach to save America's river ecosystems. Island Press, Washington, DC.

Fausch, K.D., and R.J. White. 1981. Competition between brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) for positions in a Michigan stream. Can. J. Fish. Aquat. Sci. 38: 1220-1227.

Fernandez, P.J. and P.C. Rosen. 1996. Effects of the introduced crayfish *Orconectes virilis* on native aquatic herpetofauna in Arizona. Final Report. Crayfish Impacts on Wetland Herpetofauna. Heritage Program, Arizona Game and Fish Department. Phoenix, Arizona.

Fofonoff, P.W., G.M. Ruiz, A.H. Hines, and L. McCann. 1998. Overview of biological invasions in the Chesapeake Bay region: summary of impacts on native biota. *In:* G.D. Therres, ed., Conservation of Biological Diversity: A Key to the Restoration of the Chesapeake Bay Ecosystem and Beyond. Maryland Dept. Natural Resources, Annapolis, MD.

Foster, J. 1995. Personal communication with J. Foster, Maryland Dept. Natural Resources, Tidewater Administration, Annapolis, MD.

Frissell, C.A. 1997. Ecological principles p.p 96-115 in J.E. Williams, C.A. Wood, and M.P. Dombeck, eds. Watershed restoration: principles and practices. American Fisheries Society, Bethesda, MD.

George, A. 2005. Personal communication with A. George, PhD candidate, University of St. Louis, St. Louis, MO.

Glazier, D.S. and J.L. Gooch. 1987. Macroinvertebrate assemblages in Pennsylvania (U.S.A.) springs. Hydrobiologia 150:33-43.

Glazier, D.S. 1991. The fauna of North American temperate cold springs: patterns and hypotheses. Freshwater Biology 26:527-542.

Grubbs S.A. 1999. Report: Annotated List of the Diversity, Distribution, and Conservation Status of the Stoneflies (Insecta; Plecoptera) of Maryland. Submitted to: Maryland Heritage and Biodiversity Conservation Program, Maryland Dept. of Natural Resources. 28 pp.

Hall, M., R.P. Morgan II, and R. G. Danzmann. 2002. Mitochondrial DNA analyses of mid-Atlantic USA populations of brook trout (*Salvelinus fontinalis*): the zone of contact for major historical lineages. Transactions of the American Fisheries Society 131:1140-1151.

Harris, H.S., Jr. 1975. Distributional survey (Amphibia/Reptilia): Maryland and the District of Columbia. Bulletin of the Maryland Herpetological Society 11(3):73-167.

Hart, D.D., T.E. Johnson, K.L. Bushaw-Newton, R.J. Horwitz, A.T. Bednarek, D.F. Charles, D.A. Kreeger and D.J. Velinsky. 2002. Dam removal: challenges and opportunities for ecological research and river restoration. BioScience 52:669–681.

Hayes, T., K. Haston, M. Tsui, A. Hoang, C. Haeffele, & A. Vonk. 2002. Feminization of male frogs in the wild: waterborne herbicide threatens amphibians in parts of the United States. Nature 419:895-896

Hayes, T.B., A. Collins, M. Lee, M. Mendoza, N. Noriega, A. Stuart, and A. Vonk. 2002. Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecologically relevant doses. Proceedings of the National Academy of Sciences of the United States of America 99:5476-5480.

Hocutt, C.H., and J.R. Stauffer. 1975. Influence of gradient on the distribution of fishes in Conowingo creek, Maryland and Pennsylvania. Chesapeake Science 16(1):143-147.

Hughes, R. 2005. Personal communication. USEPA Office of Research and Development, Corvallis OR.

Hughes, R., M.S. Howlin, and P.R. Kaufmann. 2004. A Biointegrity Index (IBI) for coldwater streams of western Oregon and Washington. Trans. Am. Fish. Soc. 133:1497-1515.

Jenkins, R.E. and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD.

Karatayev, A.Y., L.E. Burlakova, and D.K. Padilla. 2002. Impacts of Zebra Mussels in Aquatic Communities and Their Role as Ecosystem Engineers. Pages 433-446 in Erikki Leppakoski, Stephan Gollasch and Sergej Olenin, editors. Invasive Aquatic Species of Europe, Distribution, Impacts, and Management. Kluwer Academic Publishers, London.

Kilian, J.V. 2004. Fish assemblages in non-tidal streams of Maryland: The influence of assemblage spatial variability on the Index of Biotic Integrity. Masters Thesis. Frostburg State University. Frostburg, Maryland.

Kinziger, A.P., R.L. Raesly, and D.A. Neely. 2000. New species of *Cottus* (Teleostei: Cottidae) from the middle Atlantic eastern United States. Copeia 4:1007-1018.

Kellert, R.S., and E.O. Wilson. 1993. The biophilia hypothesis. Island Press, Washington D.C.

Kline, M.J., and R.P. Morgan II. 2000. Current distribution abundance, and habitat preferences of the stonecat (*Noturus flavus*) in Maryland. Prepared for Maryland Dept. of Natural Resources, Monitoring and Non-Tidal Assessment Division, Annapolis, MD. CBWP-MANTA-EA-00-07.

Krauthamer, J. and W. Richkus. 1987. Characterizations of the biology of and fisheries for Maryland stocks of American and hickory shad. Prepared for Tidewater Administration, Maryland Dept. of Natural Resources, Annapolis, MD.

Lasenby, T.A. and S.J. Kerr. 2001. Brown trout stocking: An annotated bibliography and literature review. Fish and Wildlife Branch, Ontario Ministry of Natural Resources. Peterborough, Ontario. 187 p. + appendices

Lee, D.S. 1976. Aquatic zoogeography of Maryland. Atlantic Naturalist 31(4):147-157.

Lee, D.S., S. Platania, C.R. Gilbert, R. Franz, and A. Norden. 1981. A revised list of the freshwater fishes of Maryland and Delaware. Proc. Southeastern Fishes Council 3(3):1-10.

Levin, P.S. and D.A. Levin. 2002. The real biodiversity crisis. American Scientist 90, 6-8.Northern Prairie Wildlife Research Center. 1998. Wetlands: losses in the United States. U.S. Geological Survey [online], Wash., D.C. http://www.npwrc.org/resource/othrdata/wetloss/summary.htm.

Lorbinske, R.J., A. Ali, and I.J. Stout. 1997. Benthic macroinvertebrates and selected physico-chemical parameters in two tributaries of the Wekiva River, Central Florida, USA. Med. Entomol. Zool. 48:219-231.

Loughman, Z. 2005. Personal communication. Marshall University, Huntington, West Virginia.

Ludyanskiy, M.L., D. McDonald, and D. MacNeill. 1993. Impacts of the zebra mussel, a bivalve invader. BioScience, 43:533-544.

Marsden, J.E. 1992. Integrated Pest Management in Freshwater Systems – Lessons for the Zebra Mussel Invasion in North America. Pages 109-116 in World Fisheries Congress, author. Protection of Aquatic Biodiversity: Proceedings of the World. Science Publishers, Lebanon, NH.

Master, L. 1990. The imperiled status of North American aquatic animals. Biodiversity Network News 3:1-2, 7-8.

McGregor, M.A. 1999. An introduction to the crayfishes of Maryland. Virginia Dept. Game and Inland Fisheries, Wildlife Diversity Division, Forest, VA.

Meffe, G.K. and P.C. Marsh. 1983. Distribution of aquatic macroinvertebrates in the Sonoran Desert springbrooks. Journal of Arid Environments 6:363-371.

Meredith, W.G. and F.J. Schwartz. 1960. Maryland Crayfishes. Educational Series 46. Maryland Department of Research and Education. Solomons, Maryland.

Merritt, R.W., and K. W. Cummins. Editors. 1996. An Introduction to the Aquatic Insects of North America. Third Edition. Kendall Hunt Publishing Co., Dubuque, Iowa. 862 pp.

Morgan II, R.P. and R. Danzmann. 2001. The evolutionary significance of Maryland brook trout populations. p.p. 225-232. *In:* G. D. Therres (ed.), Conservation of Biological Diversity: A key to the restoration of the Chesapeake Bay diversity and beyond. Maryland Dept. of Natural Resources, Annapolis, MD.

Neely. D.A. 1999. Systematics, zoogeography, and insularization of eastern populations of banded sculpins (Teleostei: Cottidae). M.S. Thesis, Frostburg State University.

Noss, R.F., and A.Y. Cooperrider. 1994. Saving nature's legacy. Island Press, Washington, D.C.

Olsen, T.M., D.M. Lodge, G.M. Capelli, and R.J. Houlihan. 1991. Mechanisms of impact of an introduced crayfish (*Orconectes rusticus*) on littoral congeners, snails, and macrophytes. Canadian Journal of Aquatic Sciences 48:1853-1861.

Omernik, J.M. and R.G. Bailey. 1997. Distinguishing Between Watersheds and Ecoregions. Journal of the American Water Resources Association 33:935-949.

Ortmann, A.E. 1919. A monograph of the naiads of Pennsylvania. Part III: Systematic account of the genera and species. Memoirs of the Carnegie Museum 8(1):1-834.

Petranka, J. 1998. Salamanders of the United States and Canada. Washington and London: Smithsonian Institution Press.

Pflieger, W.L., C.A. Taylor, M.L. Warren Jr., J.F. Fitzpatrick Jr., H.H. Hobbs III, R.F. Jezerinac, and H.W. Robison. 1996. Conservation status of crayfishes of the United States and Canada. Fisheries 21(4):25-38.

Phelps, H.L. 1994. The Asiatic clam (*Corbicula fluminea*) invasion and system-level ecological change in the Potomac River estuary near Washington, D.C. Estuaries 17: 614-621.

Pimentel, D. 1998. Economic and environmental benefits of biological diversity in the state of Maryland. *in* G.D. Therres, ed., Conservation of biological diversity: a key to the restoration of the Chesapeake Bay ecosystem and beyond. Maryland Dept. Natural Resources, Annapolis, MD.

PKF Consulting. 1995. Attitude survey of Maryland residents regarding Greenways and Open Space. Report Findings for the Maryland Greenways Commission.

Raesly, R.L. 2005. Personal communication. Frostburg State University Dept. Biology, Frostburg, MD.

Raesly, R.L. Unpublished data. Frostburg State University Dept. Biology, Frostburg, MD.

Raesly, R.L. and P.F. Kazyak. 2004. Maryland rare fishes survey 2002-2004. Final Report submitted to Maryland Dept. Natural Resources, Maryland Natural Heritage Program, Annapolis, MD.

Relyea, R.A. 2005. Growth and survival of five amphibian species exposed to combinations of pesticides. Environmental Toxicology and Chemistry 23:1737-1742.

Ricciardi, A., and J.B. Rasmussen. 1999. Extinction rates of North American freshwater fauna. Conservation Biology 13:1220-1222.

Richkus, W.A., P. Jacobson, A. Ranasinghe, A. Shaughnessy, J. Chaillou, P. Kazyak, C. DeLisle, and R. Batiuk. 1994. Basin-specific characterizations of Chesapeake Bay Living Resources Status. Prepared for the USEPA Chesapeake Bay Program, Annapolis, MD.

Ricciardi, A. and J.B. Rasmussen. 1999. Extinction rates of North American freshwater fauna. Conservation Biology 13:1220-1222.

Richter, B.D., D.P. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11: 1081-1093.

Rosen, P.C. and P.J. Fernandez. 1996. Evidence for crayfish effects on Sonoran mud turtles (*Kinosternon sonoriense*) and associated fauna in a central Arizona stream. Final Report. Crayfish Impacts on Wetland Herpetofauna. Heritage Program, Arizona Game and Fish Department. Phoenix, Arizona.

Roth, N.E., M.T. Southerland, G. Mercurio, J.C. Chaillou, P.F. Kazyak, S.A. Stranko, A.P. Prochaska, D.G. Heimbuch, and J.C. Seibel. 1999. State of the Streams: 1995-1997 Maryland Biological Stream Survey Results. Maryland Dept. Nat. Resources CBWP-MANTA-EA-99-6.

Sauls, B., D. Dowling, J. Odenkirk, and E. Cosby. 1998. Catfish populations in Chesapeake Bay. EPA 903-R-98-001. Prepared for Fishery Management Plan Workgroup, Living Resources Subcommittee, Chesapeake Bay Program. Annapolis, MD.

Schwartz, F.J., R. Rubelmann, and J. Allison. 1963. Ecological population expansion of the introduced crayfish, *Orconectes virilis*. Ohio Journal of Science 63:266-273.

Semlitsch, R.D., and J.B. Jensen. 2001. Resolving the distinction between buffer zones and core habitat. Missouri Chapter of the Society for Conservation Biology, Glade 4:7-11.

Soule, M.E., J.A. Estes, J. Berger, and C.M. Del Rio. 2003. Ecological Effectiveness: conservation goals for interactive species. Conservation Biol. 17: 1238-1250.

Southerland, M.T., N.E. Roth, and S.K. Patty. 1998. Freshwater biodiversity hotspots in Maryland. *In* G.D. Therres, ed., Conservation of biological diversity: a key to the restoration of the Chesapeake Bay ecosystem and beyond. Maryland Dept. Natural Resources, Annapolis, MD.

Southerland, M., G. Rogers, P. Kazyak, M. Kline, D. Boward, R. Morgan, and S. Stranko. 2005, *in prep*. Development of New Fish and Benthic Macroinvertebrate Indices of Biotic Integrity for Maryland Streams. Report to Monitoring and Non-Tidal Assessment Division, Maryland Dept. of Natural Resources, Annapolis, MD.

Stranko, S.A., M.K. Hurd, and R.J. Klauda. 2005. *in press*. Environmental Monitoring and Assessment.

Strayer, D.L., and L.C. Smith. 1996. Relationships between zebra mussels (*Dreissena polymorpha*) and unionid clams during the early stages of the zebra mussel invasion of the Hudson River. Freshwater Bio. 36:771-779.

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E. Young, A.S.L. Rodrigues, D.L. Fischman, and R.W. Waller. 2004. Status and trends in amphibian declines and extinctions worldwide. Science express.

Thompson, E.L. 1984. A report on the status and distribution of the Jefferson salamander, green salamander, mountain earth snake, and northern coal skink in Maryland. Pp. 338–351. In: Threatened and Endangered Plants and Animals of Maryland. Maryland Natural Heritage Program Special Publication 84-I.

TNC (The Nature Conservancy). 1997. Species report card: the state of US plants and animals.

U.S. Environmental Protection Agency. 2003. FIFRA Scientific Advisory Panel Report. SAF Report No. 2003-01.

U.S. Geological Survey (USGS). 2005 GAP Analysis Program. USGS, Biological Resources Division. http://www.gap.uidaho.edu/.

Ward, J. V. and R. G. Dufford, 1979. Longitudinal and seasonal distribution of macroinvertebrates and epilithic algae in Colorado springbrook-pond system. Arch. Hydrobiol. 86:284-321.

Waters, T.F. 1983. Replacement of brook trout by brown trout over 15 years in a Minnesota stream: production and abundance. Trans. Am. Fish. Soc. 112:137-146.

Watters, G.T. 1994. An annotated bibliography of the reproduction and propagation of the Unionoidea (Primarily of North America). Ohio Biological Survey Miscellaneous Contributions No. 1, 158 pp.

Wilson, E.O. 1984. Biophilia. Harvard University Press.

Yuan, L.L., S.B. Norton. 2003. Comparing responses of macro invertebrate metrics to increasing stress. J. of the American Benthological Society 22(2):308-322.

Appendix A. Species of Greatest Conservation Need, Their Threats and Conservation Actions

Rare, Threatened, and Endangered Freshwater Fish Species of Maryland

Species Accounts

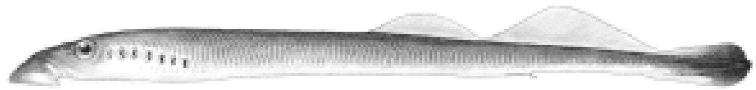
The following species accounts describe the current status of 31 freshwater fish species considered to be species of greatest conservation need (GCN), as determined by the Maryland Department of Natural Resources (COMAR 08.03.08). Statewide distributions, key habitats, species associations, stronghold watersheds, stressors, and population size estimates for each species were determined using a combination of quantitative and qualitative data provided by the Maryland Biological Stream Survey (MBSS) 1994-2004 and Dr. Richard Raesly of Frostburg State University. The MDNR Natural Heritage Program provided historical records for each species. The Maryland Department of Planning provided 1973 and 2000 land use data that were used to examine land use change in 8-digit stronghold watersheds for each species. Information on life history attributes for each species was acquired from pertinent scientific literature.

Terms used in each species account are defined as:

Stronghold Watersheds: Watersheds (8-digit) having the highest abundances and highest frequency of occurrence for the species of interest. Using quantitative data from MBSS (1994-2004) and data provided by Dr. Richard Raesly at Frostburg State University, watersheds were ranked based on raw abundance and frequency of occurrence for each species. Those watersheds that ranked in the top five were reported as the stronghold watersheds, and are considered essential for the conservation of that species in Maryland. Although these watersheds are deemed essential for the conservation of the species, conservation of populations in all other watersheds is no less important.

Species Associations: The fish species that most often occurred with the species of interest based on quantitative MBSS fish collections (1994-2004). The top five species that most often co-occurred with the species of interest are reported.

Population Estimates: Statewide population estimates for each species were determined using MBSS Round 2 data (2000-2004).



American Brook Lamprey Illustration by: D.A. Neely
Lampetra appendix

Life History:

Adult Size: 99-212 mm TL, although specimens reaching lengths of up to 300 mm have been reported in Great Lakes tributaries (Lee et al. 1980; Etnier and Starnes 1993).

Longevity: Larval stage ranges from 4-7.5 years. Metamorphosis occurs in late summer. Adults spawn in the spring following metamorphosis. Death of adults occurs following spawning (Jenkins and Burkhead 1994).

Diet: Ammocoetes feed on small algae. Adults do not feed (Jenkins and Burkhead 1994).

Fecundity: Females produce 800-3700 eggs (Etnier and Starnes 1993; Jenkins and Burkhead 1994).

Spawning: Spawning occurs in spring following adult metamorphosis, in stream temperatures ranging from 6.8-20.5 °C (Jenkins and Burkhead 1994). Spawning was reported to occur in late-March to early-April in Delaware (Rhode et al. 1976) and Virginia (Jenkins and Burkhead 1994). Although information is unavailable, the spawning period in Maryland most likely approximates that of Delaware and Virginia. Adults aggregate over gravel substrate in riffle/run habitats (Jenkins and Burkhead 1994).

Habitat: American brook lamprey is a non-parasitic species inhabiting low gradient, warmwater to moderate gradient, coolwater streams (Jenkins and Burkhead 1994). Although associated with upland areas throughout most of its range, Maryland populations of this species are confined to low gradient, warmwater streams within the Coastal Plain of the western shore of Chesapeake Bay. Ammocoetes are generally associated with mud-sand substrates (Lee et al. 1980). Spawning occurs over gravel substrate in riffle/run habitats (Jenkins and Burkhead 1994).

Migration: Adults migrate locally to riffle/run habitats over gravel substrate for spawning.

Distribution and Abundance:

Distribution: American brook lamprey has a geographic distribution in the western Chesapeake Bay drainage that ranges from the Patuxent River in Maryland to the James River in Virginia (Jenkins and Burkhead 1994). In Maryland, this species is known recently from Little Paint Branch of the Anacostia River and Piscataway Creek (both located in the Potomac Washington Metropolitan basin), as well as Western Branch and the Little, Middle, and Lower Patuxent River (Fig. A-1). Historic data (Knapp 1965) suggest that this species once occupied Gasheys Run in the Bush River Basin, and, by inference, tributaries along the western shore of Chesapeake Bay. However, recent sampling efforts conducted by the MBSS (1995-2004) determined that American brook lamprey is probably not present north of the Patuxent River in Maryland.

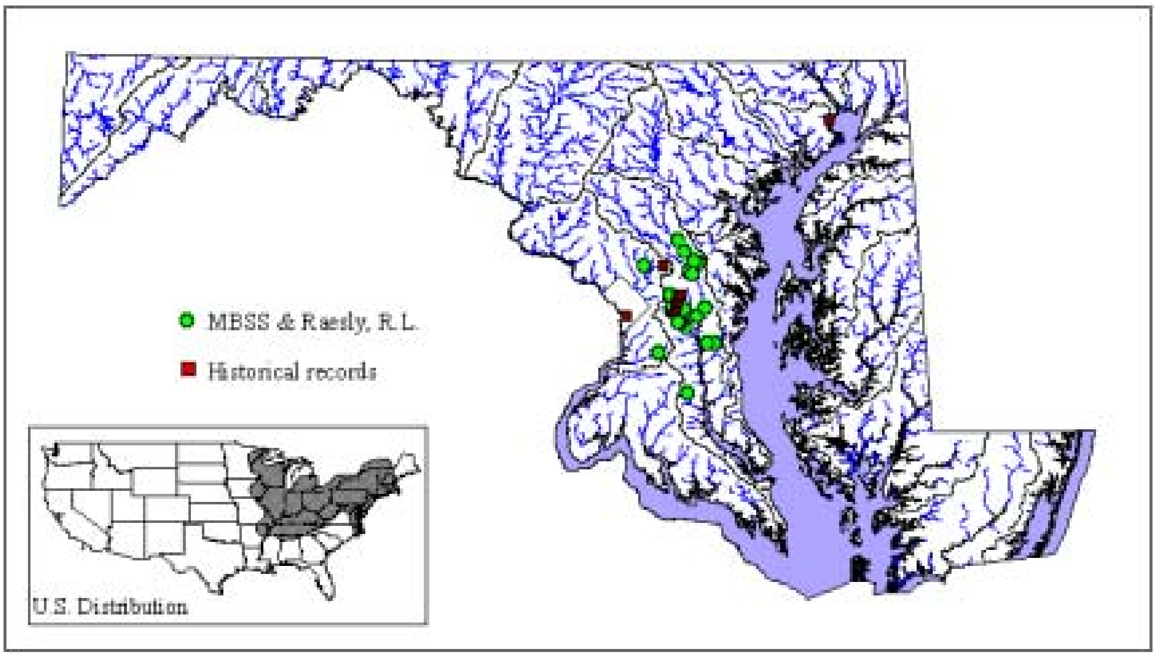


Fig. A-1. Records of American brook lamprey in Maryland.

Status and Abundance: Although considered widespread in the northern portions of its range and globally secure, American brook lamprey is considered rare or uncommon in the Mid-Atlantic region. American brook lamprey is a GCN species in Pennsylvania, Virginia, and Delaware. The distribution of this species in Maryland consists of small, disjunct populations similar to that reported in Virginia (Jenkins and Burkhead 1994). The status of American brook lamprey, as determined by the Maryland Department of Natural Resources, is Threatened (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 16,085 ± 8,853 American brook lamprey in Maryland.

Key Habitats: American brook lamprey is associated with Coastal Plain streams (MDNR 2005). The stronghold watersheds for this species are Western Branch, Patuxent River Middle, Patuxent River Upper, Little Patuxent River, and Piscataway Creek. These watersheds are essential for the conservation of American brook lamprey in Maryland.

Species Associations: A total of 51 different fish species were present at the 26 sites where American brook lamprey was collected. The five species that most often co-occurred with American brook lamprey included: American eel, tessellated darter, fallfish, white sucker, and eastern mudminnow.

Stressors: American brook lamprey is considered intolerant to anthropogenic stress (Roth et al. 1997). American brook lamprey populations in Maryland are located in watersheds undergoing continued urban development. The five stronghold watersheds for this species have experienced significant increase in urban land use from 1973 through 2000 (Table A-1). The increase in urban land use coincided with a proportional loss of forested and agricultural lands. Based on the existing state of knowledge about adverse changes in stream temperature, stream water chemistry, stream velocity, and physical habitat quality associated with increasing urbanization, the population status of American brook lamprey in Maryland should be considered as declining. A list of other stressors in watersheds with American brook lamprey populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by American brook lamprey, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-2. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

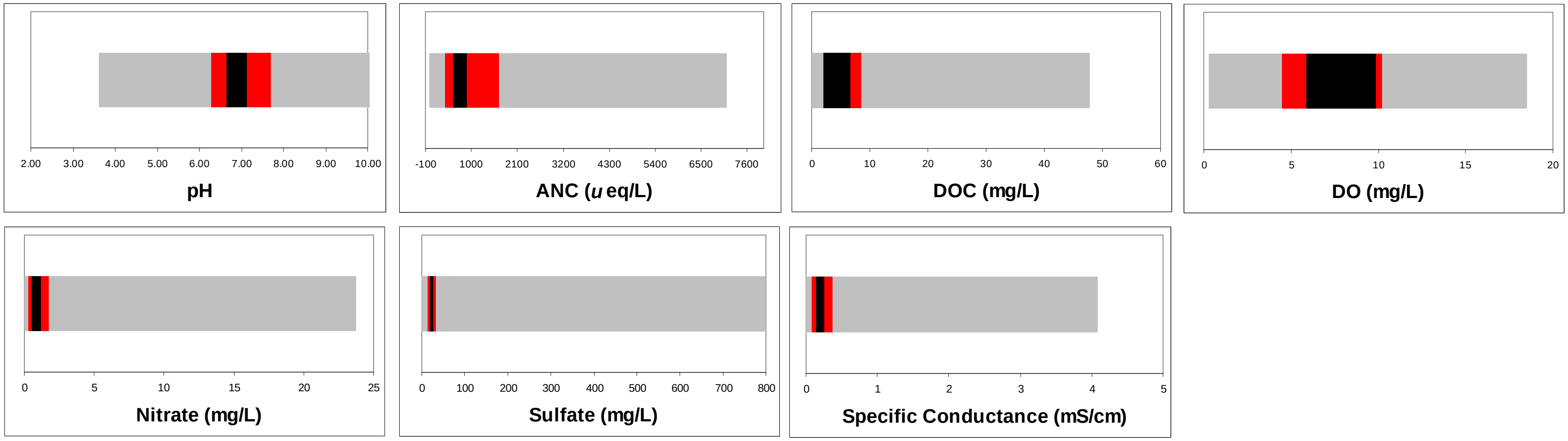
Probably the most important action needed to maintain a viable population of American brook lamprey in Maryland is to limit and fully mitigate any additional urbanization in watersheds where the species is found. Additionally, a long-term goal of improving riparian zone conditions and ultimately increasing the density of instream rootwads and large woody debris should be pursued. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified American brook lamprey populations in seven 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, given the restricted distribution of this species in

Maryland, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of American brook lamprey abundance and the extent of American brook lamprey distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable American brook lamprey habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of this species. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of American brook lamprey populations and critical habitats.

Water Chemistry



Landscape Characteristics

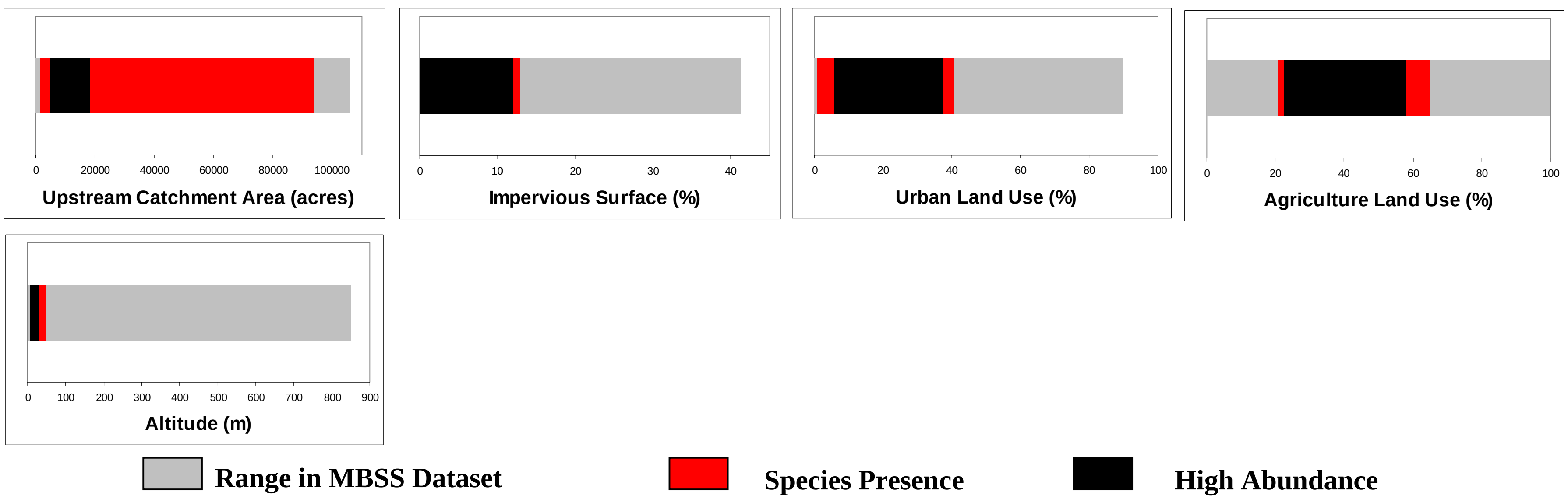


Fig. A-2: American brook lamprey range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

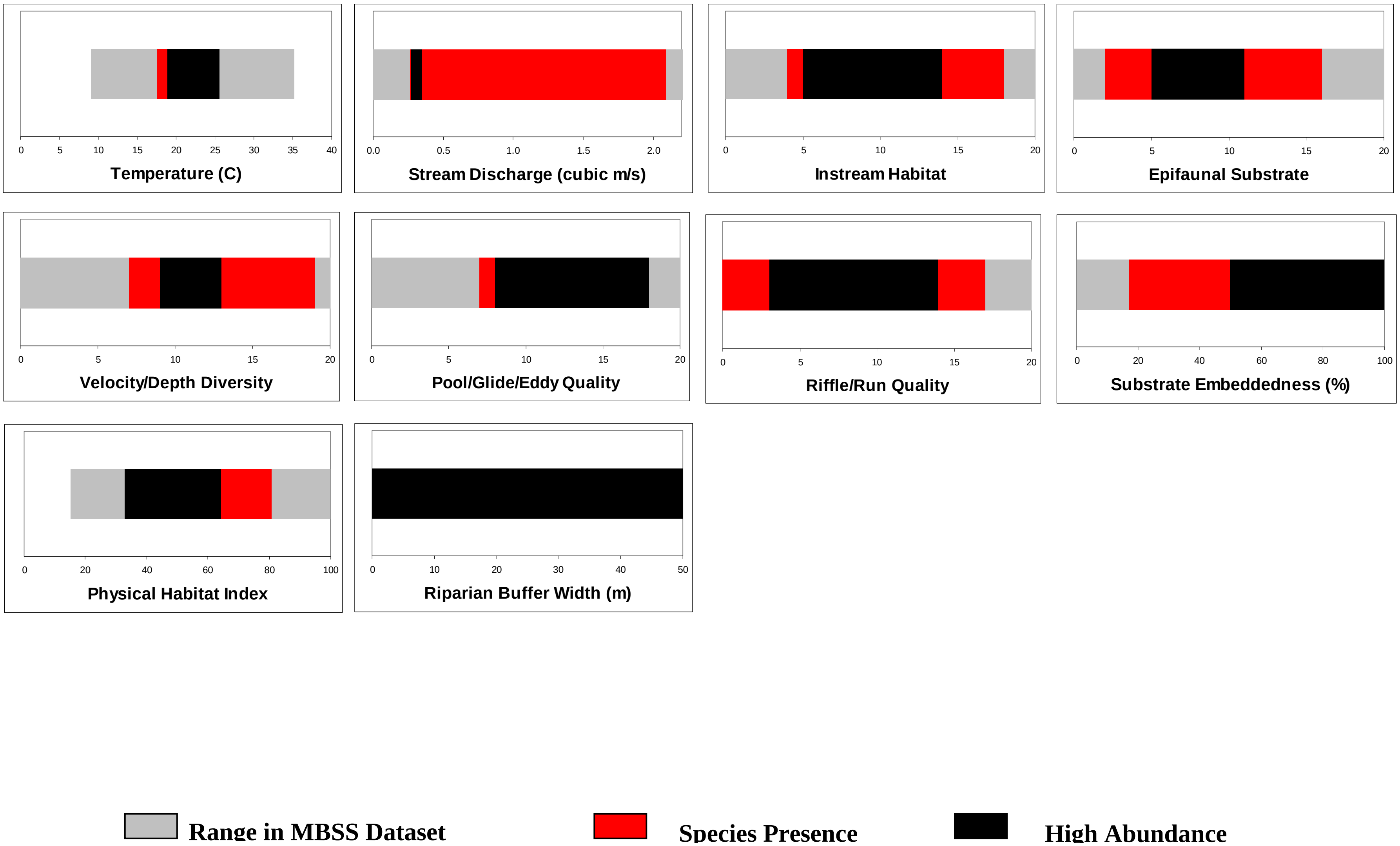
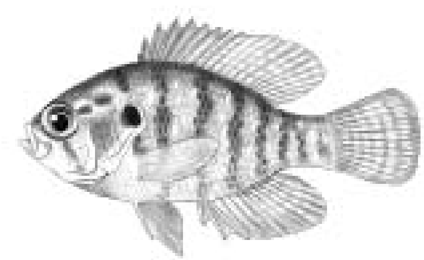


Fig. A-2: continued.



Banded Sunfish Illustration by: D.A. Neely

Enneacanthus obesus

Life History:

Adult Size: 51-75 mm SL; largest known specimen from Connecticut was 89mm TL (Cohen 1977; Lee et al. 1980; Jenkins and Burkhead 1994)

Longevity: 6 years (Cohen 1977; Jenkins and Burkhead 1994).

Diet: Aquatic insects, small crustaceans, and small mollusks (Cohen 1977; Jenkins and Burkhead 1994; Mettee et al. 1996).

Fecundity: Females produce 802-1400 eggs (Cohen 1977; Jenkins and Burkhead 1994).

Spawning: Spawning occurs from April to July in Virginia (Jenkins and Burkhead 1994) and from late spring through summer in Delaware (Wang and Kernehan 1979). Spawning in Maryland most likely approximates that of these neighboring states. Males excavate nest depressions in sand or gravel.

Habitat: Banded sunfish are found in naturally acidic, blackwater habitats, occupying slow-moving swamps, ponds, and streams (Swift et al. 1977).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Historically, the geographic distribution of banded sunfish most likely included large portions of the Coastal Plain of Maryland. Extensive stream channelization, liming of farmfields, and land alterations associated with agriculture have reduced the swampy, blackwater habitats preferred by this species on Delmarva Peninusula and the Coastal Plain of the western shore of Chesapeake Bay. Extant populations of banded sunfish are known from portions of the Bush River, West Chesapeake, Nanticoke River, Choptank River, and Pocomoke River drainage basins (Fig.A-3).

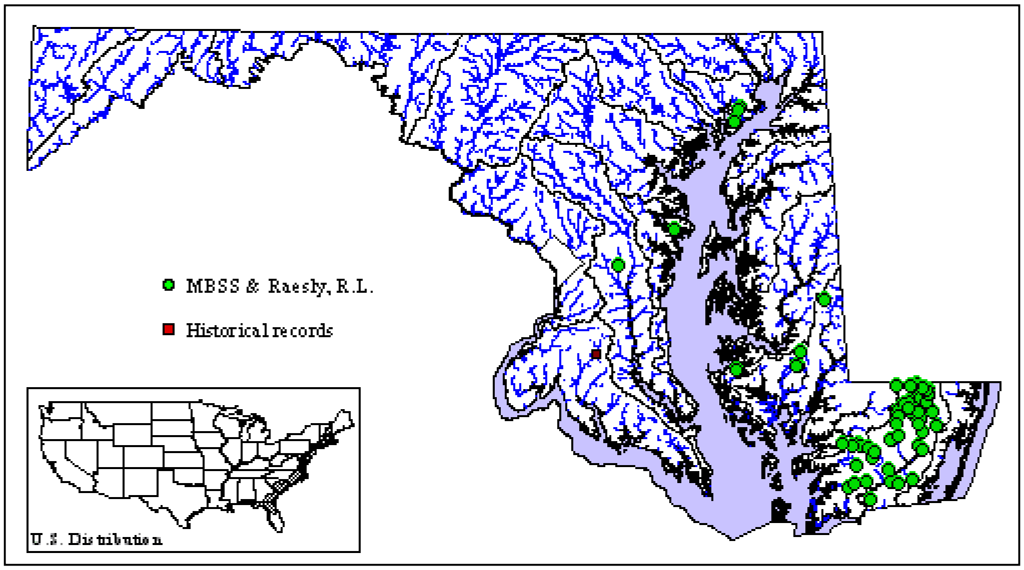


Fig.A-3. Records of banded sunfish in Maryland.

Status and Abundance: Banded sunfish is considered to be globally secure, although it is rare in parts of its range. Banded sunfish is considered a GCN species in Pennsylvania, Virginia, and Delaware. In Maryland, this species is rare. The distribution of this species consists of disjunct populations spread over the Coastal Plain. Based on quantitative MBSS electrofishing data, there are currently an estimated 83,702 ± 43,633 banded sunfish in Maryland.

Key Habitats: This species is commonly associated with blackwater streams (MDNR 2005). The stronghold watersheds for banded sunfish include Nassawango Creek, Upper Pocomoke River, Transquaking River, Lower Pocomoke River, and Marshyhope Creek. These watersheds are essential for the conservation of banded sunfish in Maryland.

Species Associations: A total of 36 different fish species were present at sites where banded sunfish was collected. The five species that most often co-occurred with banded sunfish included: eastern mudminnow, redfin pickerel, pirate perch, American eel, and golden shiner.

Stressors: Banded sunfish populations in Maryland are located in largely agricultural watersheds. Practices associated with agriculture, such as stream channelization, application of fertilizers and pesticides, removal of riparian zones, and the application of lime may reduce or degrade the swampy, slow-water habitats preferred by this species. Each of the five stronghold watersheds for this species has experienced slight increase in urban land use from 1973 to 2000 (Table A-1). Impervious surfaces associated with urban landscapes are known to negatively affect stream health, and will likely reduce banded sunfish populations if left unmitigated. A list of other stressors in watersheds with banded sunfish populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by banded sunfish, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-4. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of banded sunfish in Maryland requires the protection of critical habitats. Restoration of riparian buffers and the reduction (or full elimination) of stream channelization will serve to protect these habitats. Nitrate run-off should be limited in banded sunfish critical habitats. Additionally, management that aims to preserve or enhance the connectivity of these habitats will also benefit this species. A captive breeding program designed for the reintroduction of banded sunfish into restored habitats and areas where this species was historically extirpated will also promote long-term persistence of banded sunfish in Maryland. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified banded sunfish populations in fourteen 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of banded sunfish abundances and the extent of banded sunfish distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable banded sunfish habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of this species. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of banded sunfish populations and critical habitats.

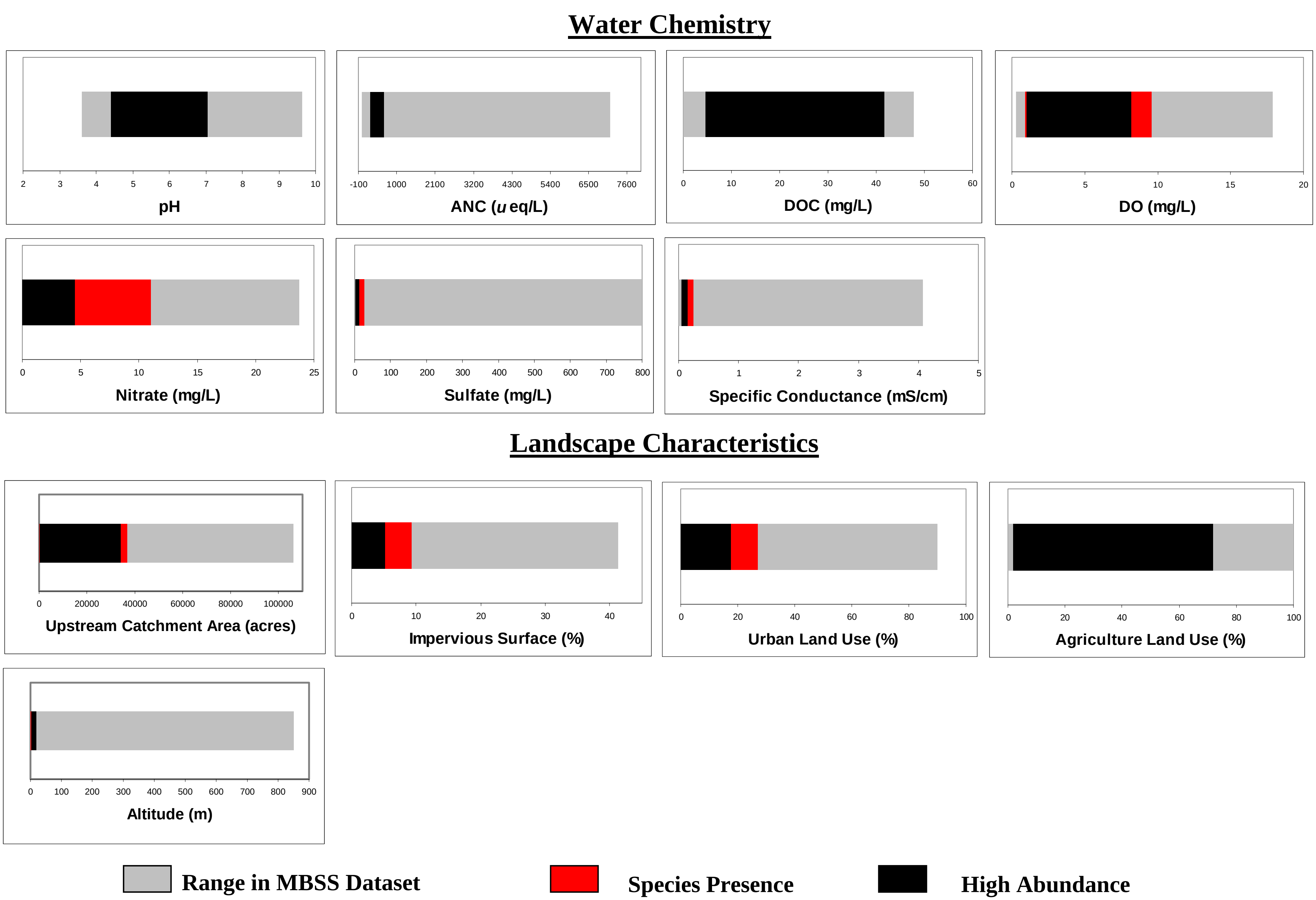


Fig. A-4: Banded sunfish range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

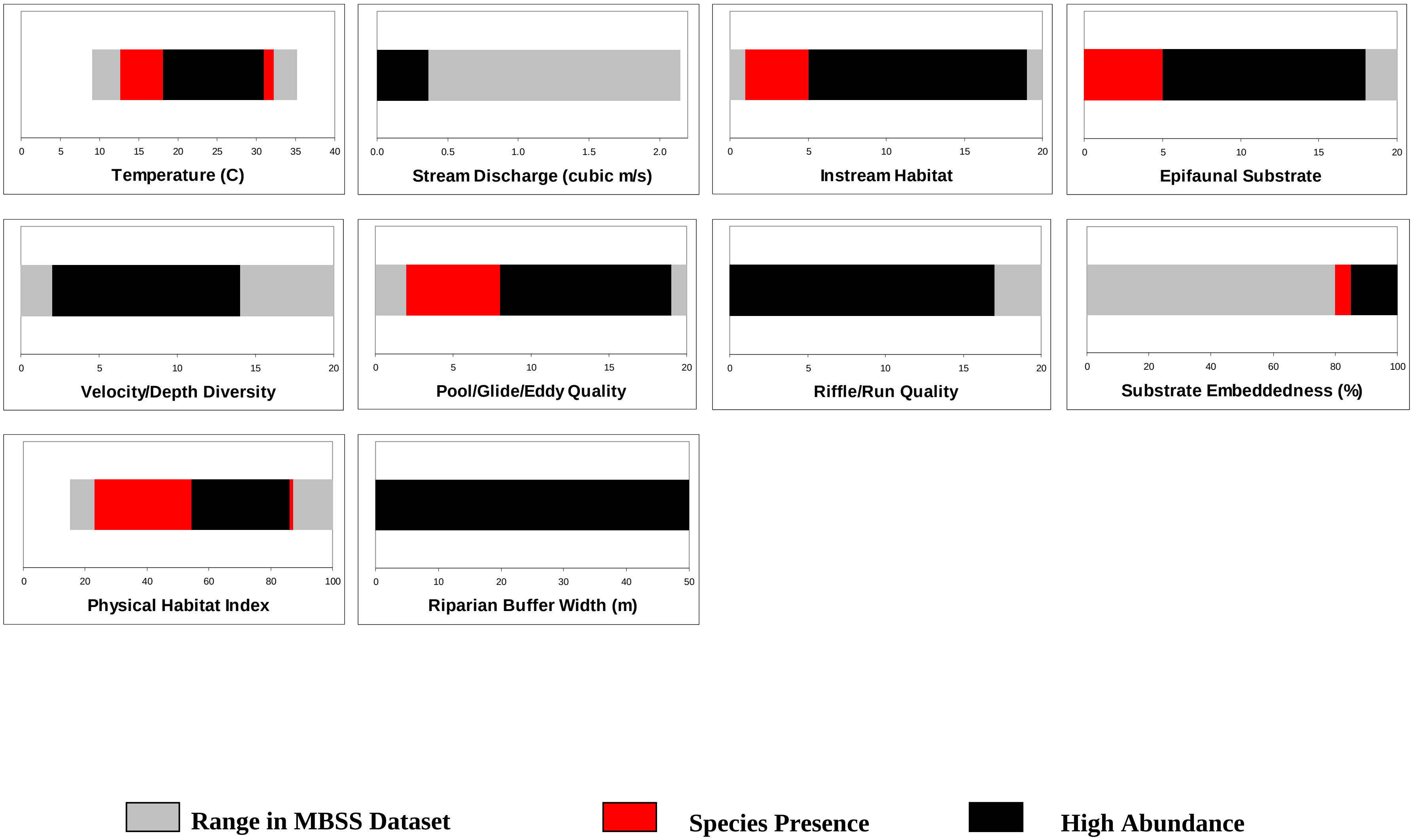


Fig. A-4: continued.

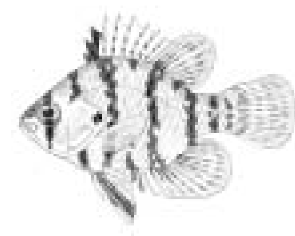


Illustration by: D.A. Neely

Blackbanded Sunfish
Enneacanthus chaetodon

<u>Life History:</u>

Adult Size: 29-66mm SL; largest known specimen from Delaware was 70mm (Schwartz 1961; Lee et al. 1980; Wujtewicz 1982; Jenkins and Burkhead 1994)

Longevity: 3-4 years (Schwartz 1961).

Diet: Small invertebrates associated with aquatic vegetation (Schwartz 1961; Jenkins and Burkhead 1994).

Fecundity: Females produce 233-920 eggs (Wujtewicz 1982).

Spawning: Spawning occurs from early May to late June in Delaware in water temperatures of 21-28 C (Wujtewicz 1982; Jenkins and Burkhead 1994). Spawning occurs over small depressions in sand or gravel beneath aquatic vegetation, in masses of algae, or in hollows beneath plant roots (Breder and Rosen 1966; Sternberg 1986; Quinn 1988; Jenkins and Burkhead 1994).

<u>Habitat:</u> Blackbanded sunfish occupy heavily vegetated, tannic-stained ponds, swamps, and slow-moving pool habitats of rivers (Lee et al. 1980; Jenkins and Burkhead 1994).

<u>Migration:</u> Unknown, but adults may make localized movements to preferred spawning habitats.

<u>Distribution and Abundance:</u>

Distribution: Historically, blackbanded sunfish have been collected in impoundments in Caroline County and Wicomico County on Delmarva Peninsula (Schwartz 1961,1964; Fig A-5). Repeated draining of these lakes and the introduction of other centrarchids are believed to have eliminated populations of blackbanded sunfish. The current distribution of blackbanded sunfish in Maryland is highly restricted, but unknown.

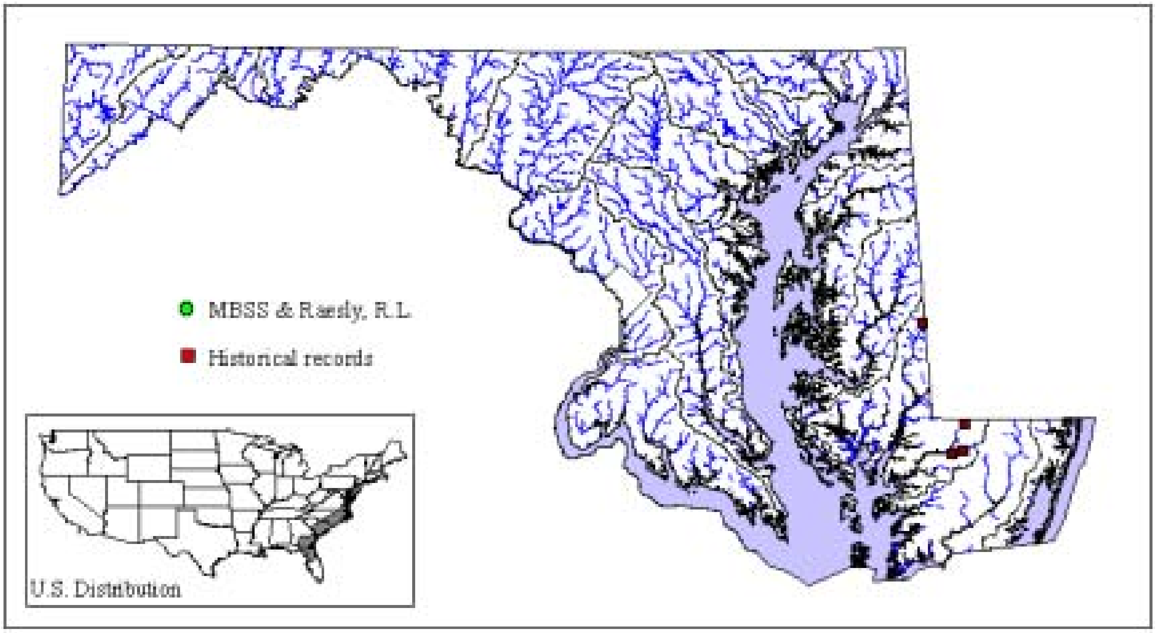


Fig. A-5. Records for blackbanded sunfish in Maryland.

Status and Abundance: Blackbanded sunfish is considered globally secure, but rare in parts of its range. Blackbanded sunfish is considered a GCN species in Pennsylvania, Virginia, and Delaware. The status of this species, as determined by the Maryland Department of Natural Resources, is Threatened (COMAR 08.03.08). The collection of one specimen of blackbanded sunfish in Marshyhope Creek in 1999 is the most recent record of this species in Maryland (MDNR Fisheries). The absence of blackbanded sunfish from recent collections (Raesly and Kazyak 2004) at historical localities emphasizes the rarity and patchiness in distribution of this species.

Key Habitats: This species is associated with blackwater streams and impoundments (MDNR 2005).

Stressors: Sites where blackbanded sunfish populations were historically collected are located in predominately agricultural watersheds. Practices associated with agriculture, such as stream channelization, removal of riparian zones, and the application of lime may reduce or degrade the swampy, slow-water habitats preferred by this species.

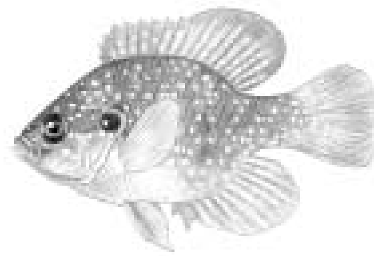
Conservation Actions:

Along with protection and restoration of slow, blackwater habitats preferred by this species, reintroduction of blackbanded sunfish in suitable habitat using stock taken from nearby Delaware populations should be considered. A captive breeding program would also supplement re-establishment of blackbanded sunfish in historical locations of Maryland.

Population control of non-native centrarchids in blackbanded sunfish habitats should also be considered.

Monitoring, Planning and Coordination Needs:

Additional sampling surveys of potential blackbanded sunfish habitat on the lower shore of Delmarva Peninsula are necessary, especially in light of the recent collection of this species in the Marshyhope Creek watershed. Targeted sampling should be focused in areas with suitable blackbanded sunfish habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of this species.



Bluespotted Sunfish Illustration by: D.A. Neely
Enneacanthus gloriosus

Life History:

Adult Size: 30-78 mm SL (Lee et al. 1980; Jenkins and Burkhead 1994; Mettee et al. 1996)

Longevity: 5 years (Werner 1972).

Diet: Aquatic insects, small invertebrates (Breder and Redmond 1929; Jenkins and Burkhead 1994).

Fecundity: Females produce 600 eggs (Occhiogrosso and Goodbred 1981).

Spawning: Spawning occurs from May to September in Virginia (Jenkins and Burkhead 1994) and from late spring through early fall in the Delaware River (Wang and Kernehan 1979). Spawning in Maryland most likely approximates that of these neighboring states. Spawning occurs over small depressions in sand or in cavities of vegetation beds (Breder and Redmond 1929; Breder and Rosen 1966; Wang and Kernehan 1979; Jenkins and Burkhead 1994).

Habitat: Bluespotted sunfish occupies pools and backwater habitats of slow moving, low-gradient streams and rivers. This species can tolerate brackish waters. It has been reported to occur in salinities as high as 12.9 ppt (Hildebrand and Schroeder 1928; Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: The geographic distribution of bluespotted sunfish is confined to the Coastal Plain of Maryland. Extant populations of this species are known from portions of West Chesapeake Bay, Patapsco River, Potomac Washington Metro, Lower Potomac, and the Patuxent River drainage basins on the western shore of Chesapeake Bay and from portions of Elk

River, Chester River, Choptank River, Nanticoke/Wicomico River, Ocean Coastal, and Pocomoke River drainage basins of Delmarva Peninsula (Fig.A-6).

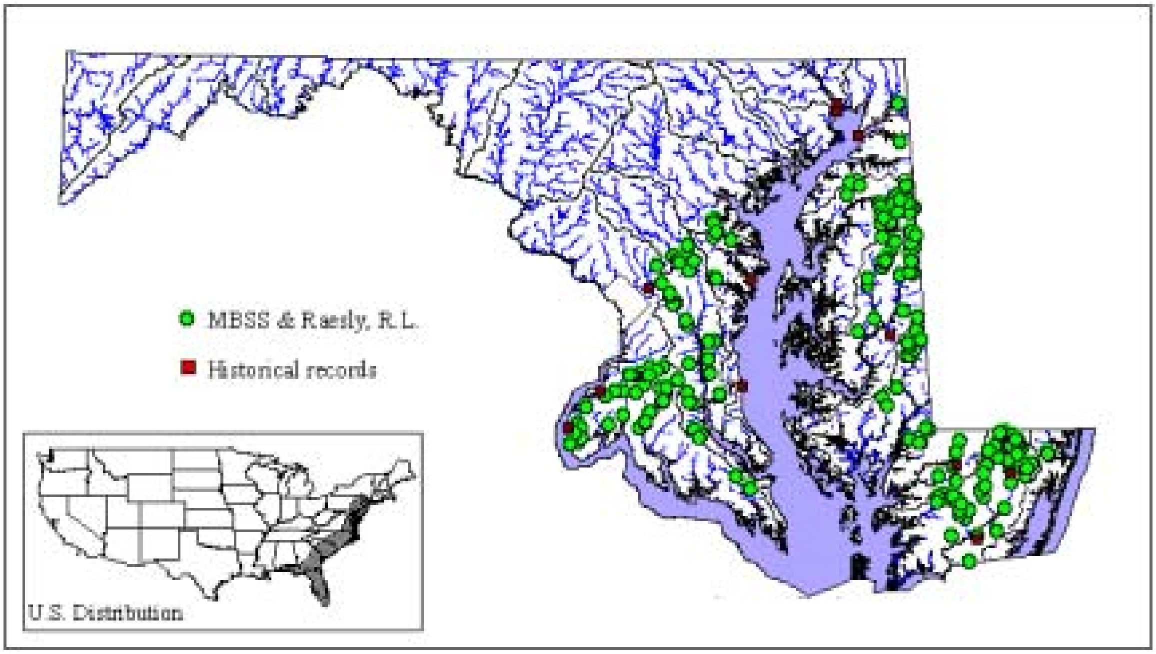


Fig. A-6. Records for bluespotted sunfish in Maryland.

Status and Abundance: Bluespotted sunfish is globally stable and is the most abundant *Enneacanthus* species in Maryland. However, this species is currently on the state "Watch List". Based on quantitative MBSS electrofishing data, there are currently an estimated 494,446 ± 108,404 bluespotted sunfish in Maryland.

Key Habitats: Bluespotted sunfish are associated with streams of the Coastal Plain (MDNR 2005). The stronghold watersheds for bluespotted sunfish include Isle of Wight Bay, Dividing Creek, Upper Pocomoke River, Manokin River, Tuckahoe Creek, Upper Chester River, and Nassawango Creek on Delmarva Peninsula, and Zekiah Swamp on the Coastal Plain of the western shore of Chesapeake Bay. These watersheds are essential for the conservation of bluespotted sunfish in Maryland.

Species Associations: A total of 61 different fish species were present at sites where bluespotted sunfish was collected. The five species that most often co-occurred with bluespotted sunfish included: eastern mudminnow, American eel, pumpkinseed, creek chubsucker, and tessellated darter.

Stressors: Bluespotted sunfish populations in Maryland are located in predominately agricultural watersheds. Practices associated with agriculture, such as stream channelization, application of fertilizers and pesticides, removal of riparian zones, and the application of lime may reduce or degrade the swampy, slow-water habitats preferred by this species. Urbanization has increased substantially in two stronghold watersheds for this species, Isle of Wight Bay and Zekiah Swamp, followed by a proportional loss of agriculture and forested lands during the period from 1973 to 2000 (Table A-1). Using a predictive/diagnostic model, reduction of forested land use associated with both farming and urbanization has been identified as a stressor that has led to reduced abundances or extirpation of bluespotted sunfish in some areas (Stranko et al. 2005). Myriad stressors associated with urban development would be expected to have a negative effect on bluespotted sunfish populations in these two watersheds. Each of the remaining stronghold watersheds experienced only slight increases in urban land use during the same 27-year period. However, land use change, if continued, could ultimately degrade critical habitats and reduce populations in these watersheds. A list of other stressors in watersheds with bluespotted sunfish populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by bluespotted sunfish, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-7. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of bluespotted sunfish in Maryland requires the protection of the critical habitats containing populations of this species. Restoration of riparian buffers and the reduction (or full elimination) of stream channelization will serve to protect critical habitats. Also, eventual reintroduction of bluespotted sunfish via captive breeding into watersheds where they been extirpated should be considered. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified bluespotted sunfish populations in 33 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of bluespotted sunfish abundance and the extent of bluespotted sunfish distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable bluespotted sunfish habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of bluespotted sunfish. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of bluespotted sunfish populations and critical habitats.

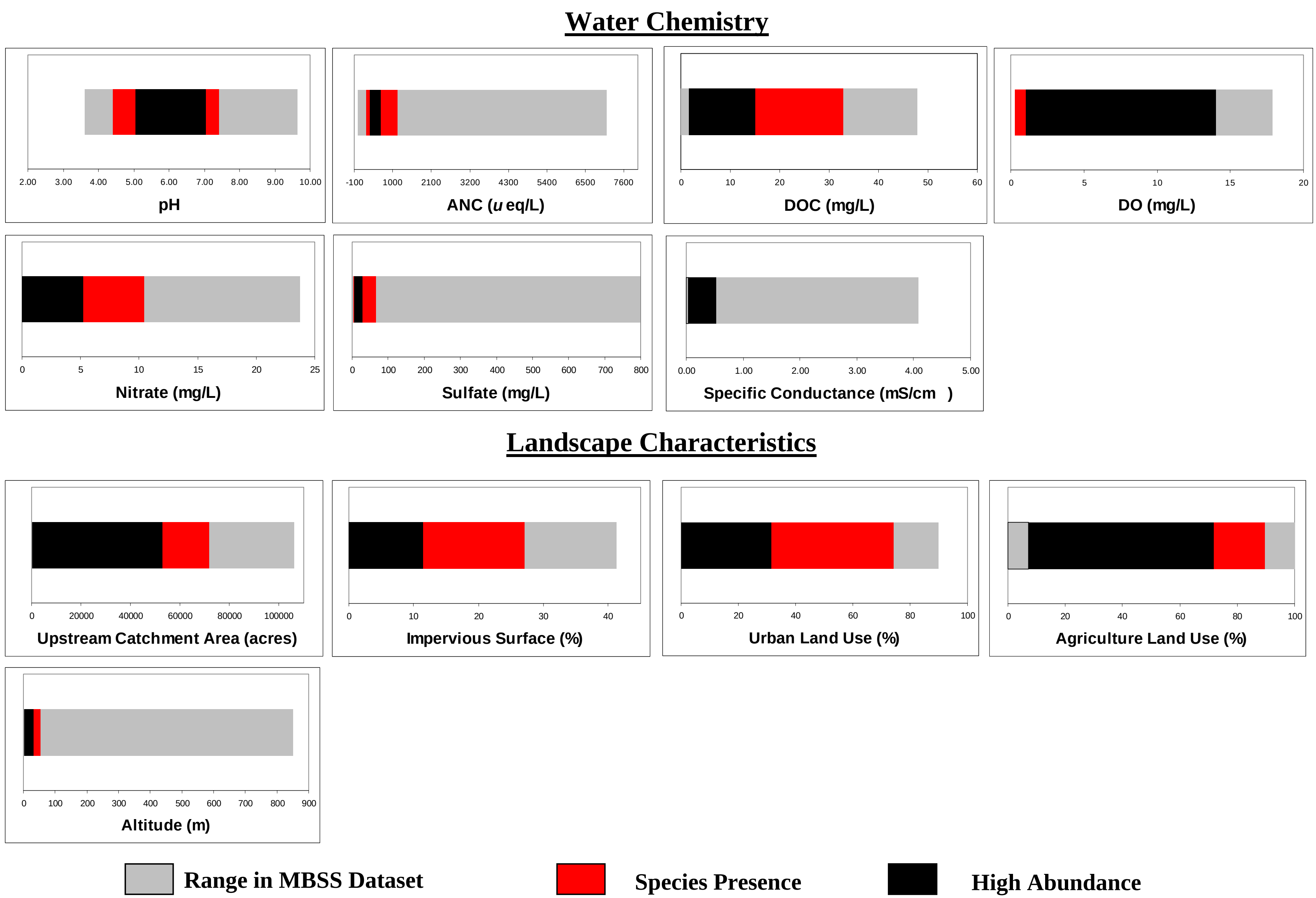


Fig. A-7: Bluespotted sunfish range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

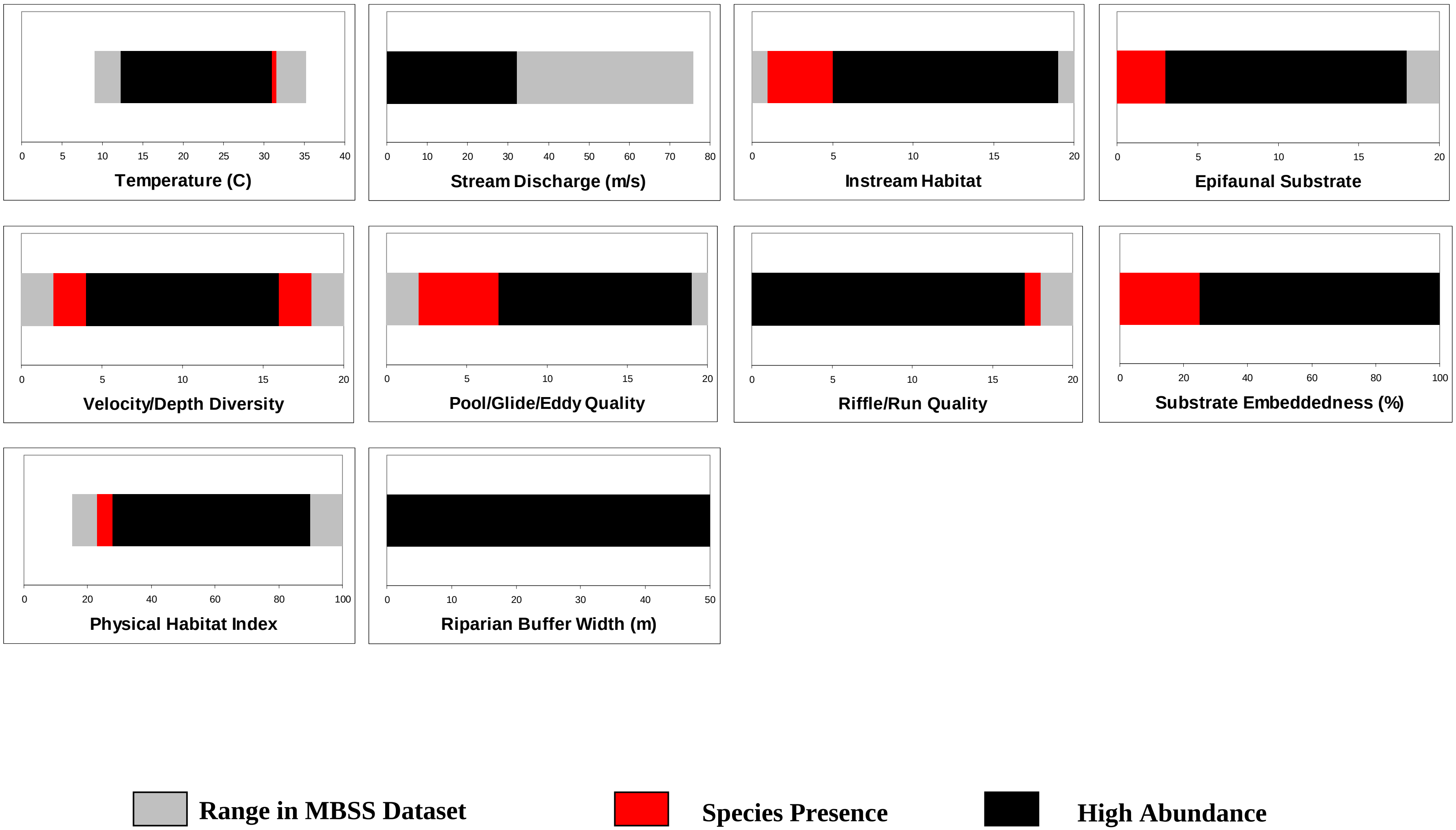
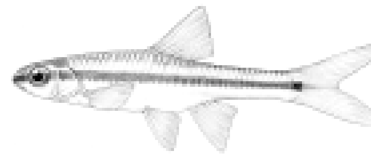


Fig. A-7: continued.



Bridle Shiner
Notropis bifrenatus

Illustration by: D.A. Neely

Life History:

Adult Size: 25-50 mm SL (Harrington 1947a, 1948a; Jenkins and Zorach 1970; Lee et al. 1980; Jenkins and Burkhead 1994).

Longevity: Maximum of 2 years (Harrington 1948a; Jenkins and Burkhead 1994).

Diet: Aquatic insects and small crustaceans; occasionally detritus and plant material (Harrington 1948b; Jenkins and Burkhead 1994).

Fecundity: Females produce 6-15 eggs per spawning; an estimated 1,062-2,110 eggs are produced in a year (Harrington 1947b, 1951; Jenkins and Burkhead 1994).

Spawning: Spawning in Virginia occurs from mid-April to July (Jenkins and Burkhead 1994). Although information is unavailable, spawning in Maryland most likely is similar to that of Virginia. Spawning occurs in pool habitats typically over submerged aquatic vegetation. Eggs are adhesive, and may adhere to vegetation (Loos and Fuiman 1978; Jenkins and Burkhead 1994).

Habitat: Bridle shiner inhabits low gradient, slow-moving streams and rivers with soft substrate and is commonly associated with aquatic vegetation. This species can tolerate low-salinity tidal waters, but is more commonly collected from freshwater streams (Jenkins and Zorach 1970; Wang and Kernehan 1979). The bridle shiner is acid-intolerant; avoiding blackwater streams with low pH (Hastings 1979).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Historically, bridle shiner has been collected in the Magothy and Severn Rivers (Schwartz 1963). This species was also reported from the Coastal Plain of Delmarva Peninsula and the Coastal Plain of southern Maryland (Lee et al. 1976, 1981). Bridle shiner was once common in tributaries of the tidal portion of the Potomac River near Washington, D.C. (Jenkins and

Zorach 1970). Records also exist for this species in tributaries to the Bush River watershed in upper Chesapeake Bay (Raesly and Kazyak 2004), tributaries to the Upper Monocacy River near Union Bridge, and tributaries to the Potomac River near Rockville (MDNR Heritage data). Despite extensive sampling by the MBSS and Raesly (2004), no extant populations of this species are known in Maryland (Fig.A-8).

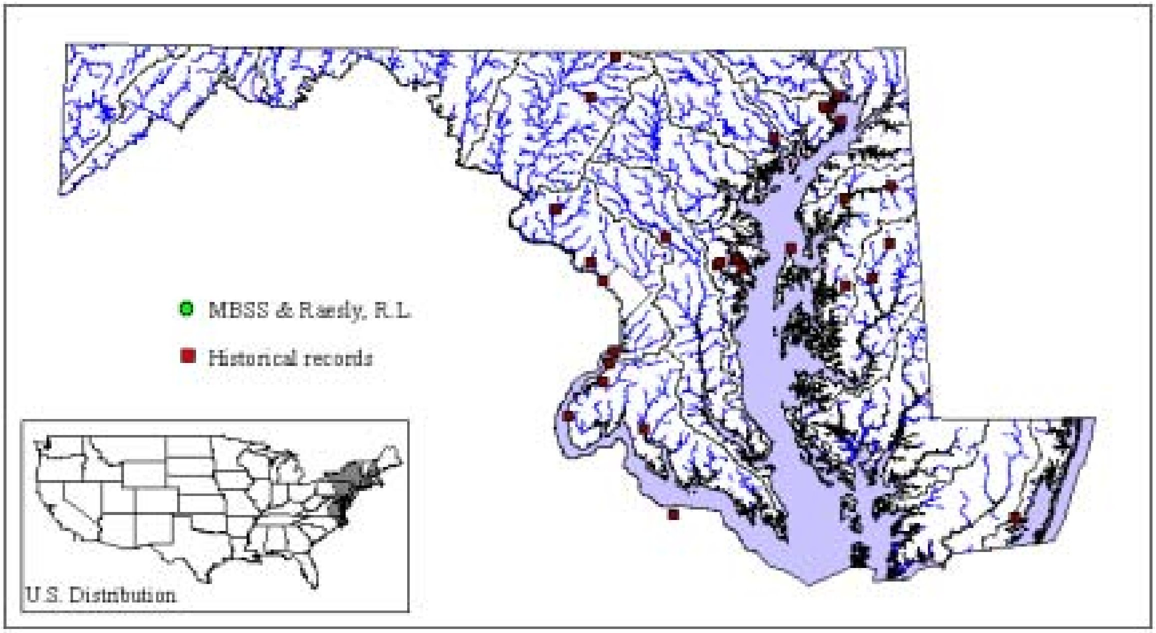


Fig. A-8. Records for bridled shiner in Maryland.

Status and Abundance: This species is a GCN species in Pennsylvania, Virginia, and Delaware. The status of this species as determined by the Maryland Department of Natural Resources is Endangered (COMAR 08.03.08). The absence of bridle shiner from recent collections made at historical localities suggests that this species may be extirpated from Maryland (Raesly and Kazyak 2004).

Key Habitats: This species is associated with Coastal Plain streams (MDNR 2005).

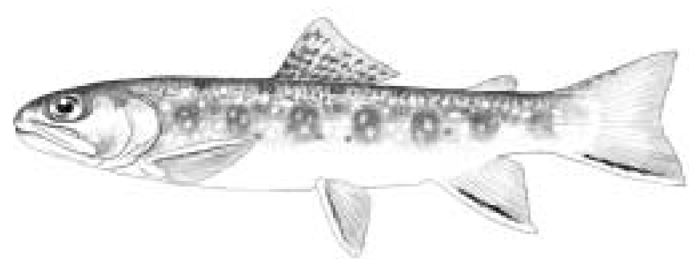
Stressors: Sites where bridle shiner populations were historically collected are located in predominately agricultural watersheds. Practices associated with agriculture, such as stream channelization, removal of riparian zones, and the application of lime may reduce or degrade the habitats preferred by this species.

Conservation Actions:

Along with protection and restoration of slow water habitats preferred by this species, reintroduction of bridle shiner using stock taken from nearby Pennsylvania populations should be considered a high priority. A captive breeding program would also supplement re-establishment of bridle shiner in historical locations of Maryland.

Monitoring, Planning and Coordination Needs:

Additional sampling surveys of potential habitat in historical locations are necessary to determine whether or not viable populations of bridle shiner still reside in Maryland. Targeted sampling should be focused in areas with suitable bridle shiner habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of this species.



Brook trout Illustration by: D.A. Neely
Salvelinus fontinalis

Life History:

Adult Size: Varies over range and habitats. Adults inhabiting streams range from 146-321 mm TL. (Jenkins and Burkhead 1994).

Longevity: 3-4 years in southern stream populations (Mohn and Bugas 1980; Jenkins and Burkhead 1994).

Diet: Aquatic and terrestrial insects, and fishes (Jenkins and Burkhead 1994).

Fecundity: Females produce 100-5000 eggs (Jenkins and Burkhead 1994).

Spawning: Spawning in Virginia occurs from October to November (Lennon 1961; Mohn and Bugas 1980; Jenkins and Burkhead 1994). Females construct redds in gravel. Redds are defended primarily by the female, at times by both male and female, and are abandoned once spawning is complete (Needham 1961; Jenkins and Burkhead 1994).

Habitat: Brook trout inhabit moderate to high gradient coldwater streams with rocky boulder, cobble, and gravel substrate. In northern portions of its range, the brook trout is commonly found in ponds and lakes. Anadromous populations of this species are found in the coastal portions of its range (Jenkins and Burkhead 1994).

Migration: Migration of this species varies among populations throughout its range and is dependent upon latitude and climate (Lucas et al. 2001). Adults in Maryland make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Historically, the geographic distribution of brook trout included larger portions of Maryland. Declines in brook trout, Maryland's only native trout species, were reported as early as the late 1800s (Uhler and Lugger 1876). Extant populations of brook trout are known from West

Chesapeake Bay, Patapsco River, Gunpowder River, Susquehanna River, Middle Potomac River, Upper Potomac River, North Branch Potomac River, and the Youghiogheny River drainage basins (Fig.A-9).

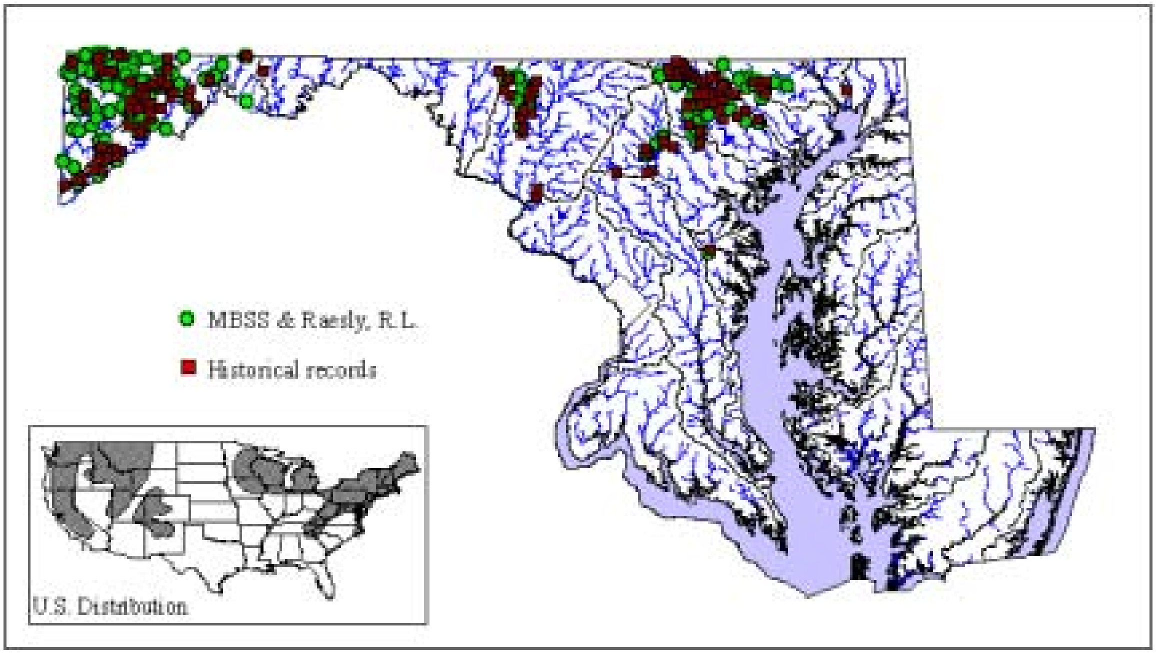


Fig. A-9. Records for brook trout in Maryland.

Status and Abundance: Brook trout is considered globally stable, although loss of brook trout populations has been reported in portions of its range (Nagel 1991). Brook trout is currently a “watch list” species in Maryland. Based on quantitative MBSS electrofishing data, there are currently an estimated 407,262 ± 69,942 brook trout in Maryland.

Key Habitats: This species is commonly associated with coldwater streams. The stronghold watersheds for brook trout include Savage River, Potomac River Upper North Branch, Upper Monocacy River, Youghiogheny River, Prettyboy Reservoir, and Wills Creek. These watersheds are essential for the conservation of brook trout in Maryland.

Species Associations: A total of 47 different fish species were present at sites where brook trout was collected. The five species that most often co-occurred with brook trout included: blacknose dace, creek chub, white sucker, longnose dace, and Blue Ridge sculpin.

Stressors: Brook trout is considered intolerant to anthropogenic stress (Roth et al. 1997). Isolation resulting from the downstream introduction of non-native species and physical barriers (e.g. stream temperatures) to dispersal has made brook trout populations in the Piedmont of Maryland vulnerable to increasing urbanization (Morgan et al. 2004). Impervious surfaces, the introduction of non-native species, the removal of riparian buffers, and groundwater withdrawals threaten the persistence of brook trout in eastern Maryland. A regional heat island effect associated with urban sprawl in Maryland is a growing threat to these coldwater species. Each of the stronghold watersheds for this species has experienced increased urban land use from 1973 to 2000 (Table A-1). Impervious surface exceeding 4 % in a watershed is known to eliminate brook trout populations, and reductions are apparent even at 0.5% (MBSS data). The affinity of brook trout for silt-free substrate for spawning lends this species vulnerable to excessive stream sedimentation commonly associated with landscape alteration. Acid mine drainage and acid deposition threaten brook trout populations in western Maryland. Additionally, projected increases in temperatures associated with global climate change will also threaten populations of this species throughout the state. A list of other stressors in watersheds with brook trout populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by brook trout, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-10. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of brook trout in Maryland requires the protection of critical coldwater habitats. Management designed to limit impervious surface, eliminate non-native species, improve riparian buffers, and limit groundwater withdrawal in brook trout watersheds will help protect the coldwater trout habitats. Soil conservation and best management practices designed to limit channel alteration, stream bank erosion, and stream sedimentation will protect brook trout spawning habitats. Additionally, management that aims to preserve or enhance the connectivity of brook trout habitats will reduce isolation of brook trout populations. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified brook trout populations in 19 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. Random sampling by MBSS has identified previously unknown populations of brook trout. Additional random and targeted surveys at finer spatial scales will improve our understanding of brook trout abundance and the extent of brook trout distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable brook trout habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of brook trout. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of brook trout populations and critical coldwater habitats.

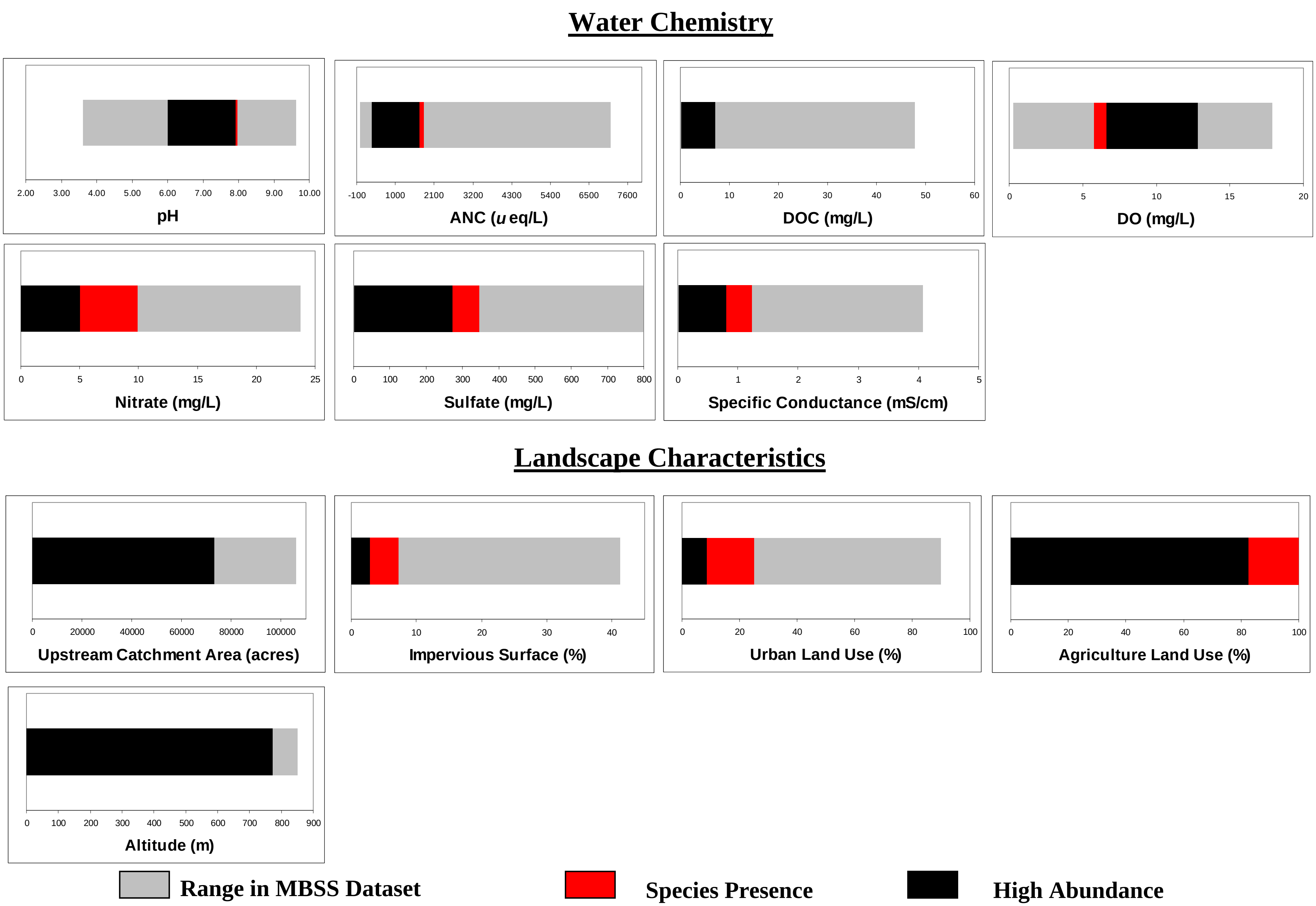


Fig. A-10: Brook trout range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

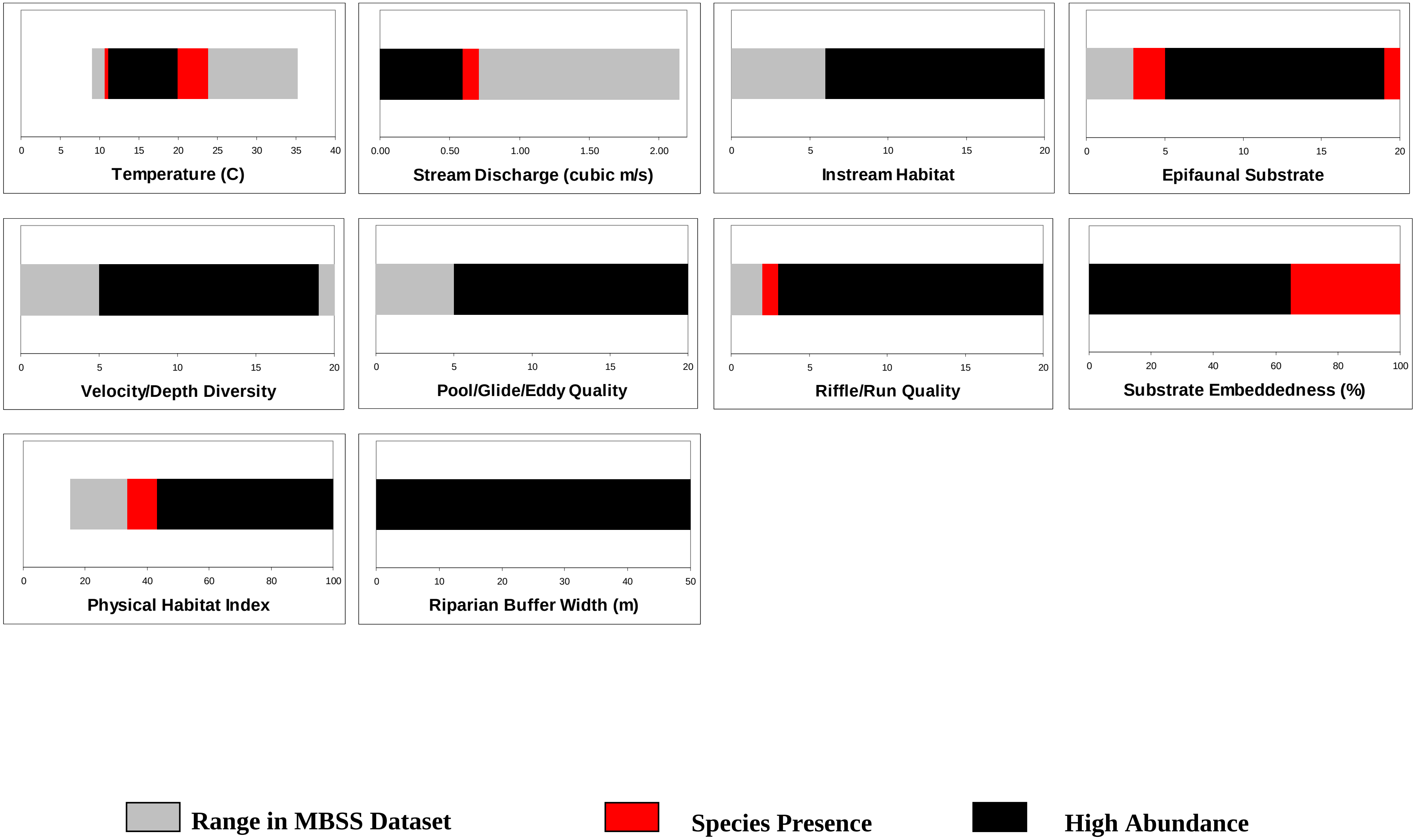


Fig. A-10: continued.

Cheat minnow
Pararhinichthys bowersii

Illustration by: D.A. Neely

Life History:

Adult Size: 120 mm TL.

Longevity: unknown

Diet: unknown, although most likely similar to *Nocomis micropogon* and *Rhinichthys cataractae*.

Fecundity: unknown

Spawning: unknown

Habitat: Cheat minnow occupies runs and pool habitats with gravel and cobble substrates in coldwater or coolwater streams.

Migration: unknown

Distribution and Abundance:

Distribution: One historic record exists for Cheat minnow (originating from hybridization between *Nocomis micropogon* and *Rhinichthys cataractae*) in Maryland (Fig A-11). One specimen of Cheat minnow was collected from the Youghiogheny River at Hoyes Run in Garrett County, Maryland (Hendricks 1980). Extensive sampling by the MBSS (1994-2004) has not identified any extant populations of Cheat minnow in the state.

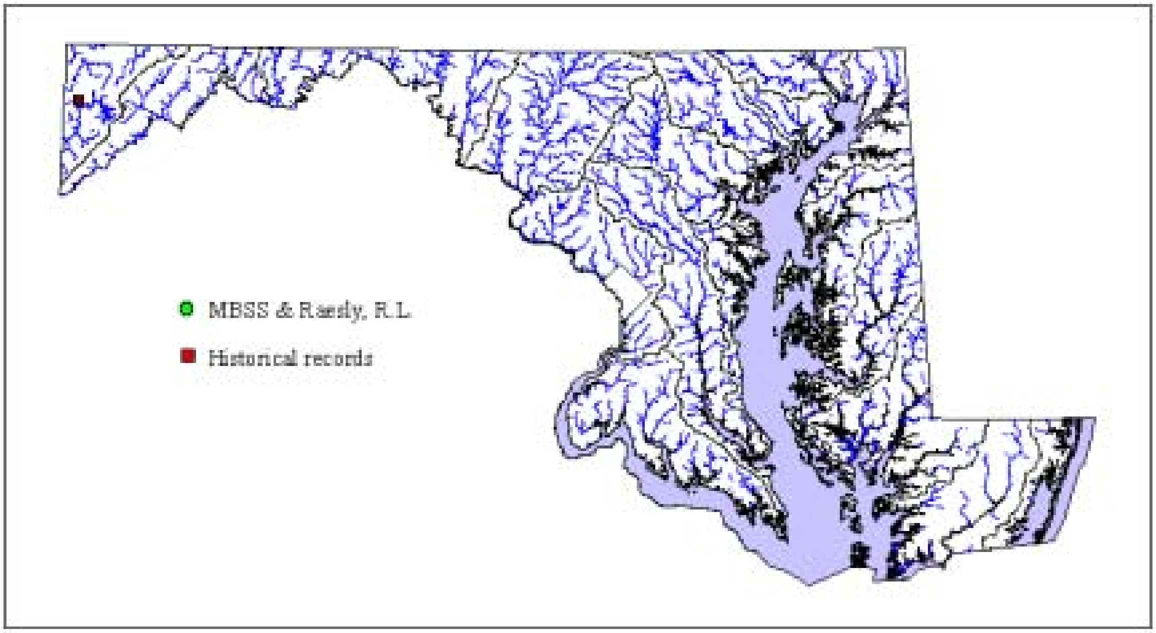


Fig.A-11. Records for Cheat minnow in Maryland.

Status and Abundance: Cheat minnow is a GCN species in Pennsylvania. The status of this species, as determined by the Maryland Department of Natural Resources, is Endangered Extirpated (COMAR 08.03.08).

Key Habitats: This species is associated with Highland streams (MDNR 2005).

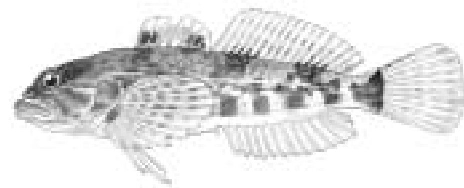
Stressors: Data on stressors on Cheat minnow populations are limited. Stressors common to watersheds of western Maryland likely to influence populations of this species are acid mine drainage, acid deposition, and stream degradation commonly associated with agriculture and forest logging practices.

Conservation Actions:

A captive breeding program designed for the reintroduction of Cheat minnow into tributaries of the Youghiogheny River historically known to harbor this species should be considered.

Monitoring, Planning and Coordination Needs:

Additional sampling surveys of historical cheat minnow habitats in the Youghiogheny River drainage basin are necessary to ascertain whether or not viable populations of cheat minnow still reside in Maryland. Targeted sampling should be focused in areas with suitable cheat minnow habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of this species.



Checkered sculpin
Cottus sp.

Illustration by: D.A. Neely

Life History:

Adult Size: 39-64 mm SL, male specimen measuring 74 mm SL was collected in Virginia (Raesly et al. 2005; Jenkins and Burkhead 1994).

Longevity: Unknown.

Diet: Mayflies, caddisflies, and chironomids, some crayfish (Raesly unpublished data).

Fecundity: Unknown.

Spawning: Gravid females were found in Antietam Creek in April. By 10 April, some spent females were observed.

Habitat: Checkered sculpin inhabits cold, spring-fed moderate and high gradient streams (Raesly et al. 2005).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: This species is endemic to the Great Valley of the Potomac River Basin. Although believed to be historically widespread, relict populations of checkered sculpin are currently restricted to the coldwater, spring-fed portions of the Conococheague Creek in Pennsylvania, several tributaries to the Potomac River in West Virginia, a few tributaries to the Shenandoah River in Virginia, and the Antietam Creek and Lower Monocacy River watersheds in Maryland (Raesly et al. 2005; Fig.A-12).

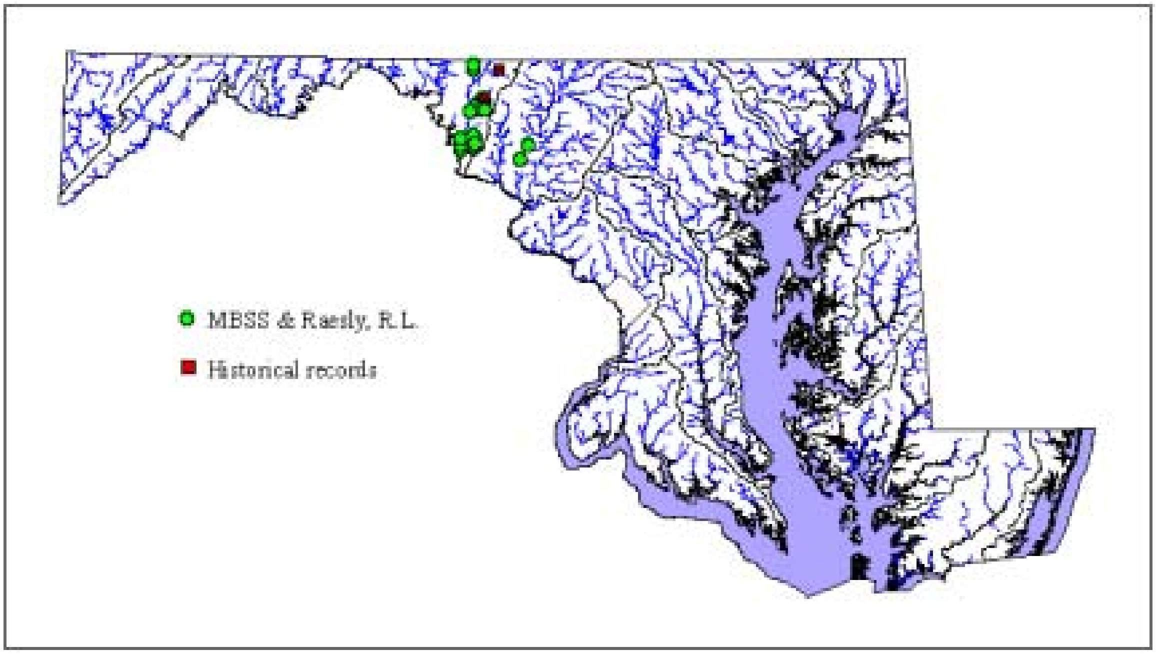


Fig. A-12. Records for checkered sculpin in Maryland.

Status and Abundance: Checkered sculpin is currently considered globally secure. However, checkered sculpin is rare in Maryland and has a restricted distribution. Checkered sculpin is a GCN species in Pennsylvania. Based on quantitative MBSS electrofishing data, there are currently an estimated 60,251 ± 41,524 checkered sculpin in Maryland.

Key Habitats Checkered sculpin is associated with spring-fed, limestone streams (MDNR 2005). The stronghold watersheds for checkered sculpin are Antietam Creek and Lower Monocacy River. These watersheds are essential for the conservation of checkered sculpin in Maryland.

Species Associations: A total of 35 different fish species were present at sites where checkered sculpin was collected. The five species that most often co-occurred with checkered sculpin included: blacknose dace, white sucker, fantail darter, pearl dace, and longnose dace.

Stressors: Given its restricted distribution and propensity for cold, spring-fed waters, this species is susceptible to stream degradation. Checkered sculpin populations in Maryland are located in predominately agricultural watersheds that are currently experiencing increased pressure associated with urban sprawl. The two stronghold watersheds, Antietam Creek and Lower Monocacy River, experienced substantial increase in urban land use from 1973 to 2000 (Table A-1). Impervious surfaces associated with urban landscapes are known to negatively affect stream health, and will likely reduce checkered sculpin populations if left unmitigated.

Groundwater withdrawal and adverse changes in stream temperatures associated with urbanization and agriculture may also reduce or degrade the coldwater, spring-fed habitats preferred by this species. A list of other stressors in watersheds with checkered sculpin populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by checkered sculpin, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-13. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of checkered sculpin in Maryland requires the protection of critical spring-fed, limestone stream habitats. Management that aims to preserve or enhance the connectivity of these habitats will also benefit this species. Restoration of riparian buffers, limits to groundwater withdrawals, and full mitigation of urbanization in the stronghold watersheds will serve to protect populations of checkered sculpin. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified checkered sculpin populations in two 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of checkered sculpin abundance and the extent of checkered sculpin distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable checkered sculpin habitat that have not been previously sampled. Targeted sampling in these areas is also likely to identify currently unknown populations of checkered sculpin. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of checkered sculpin populations and critical limestone stream habitats.

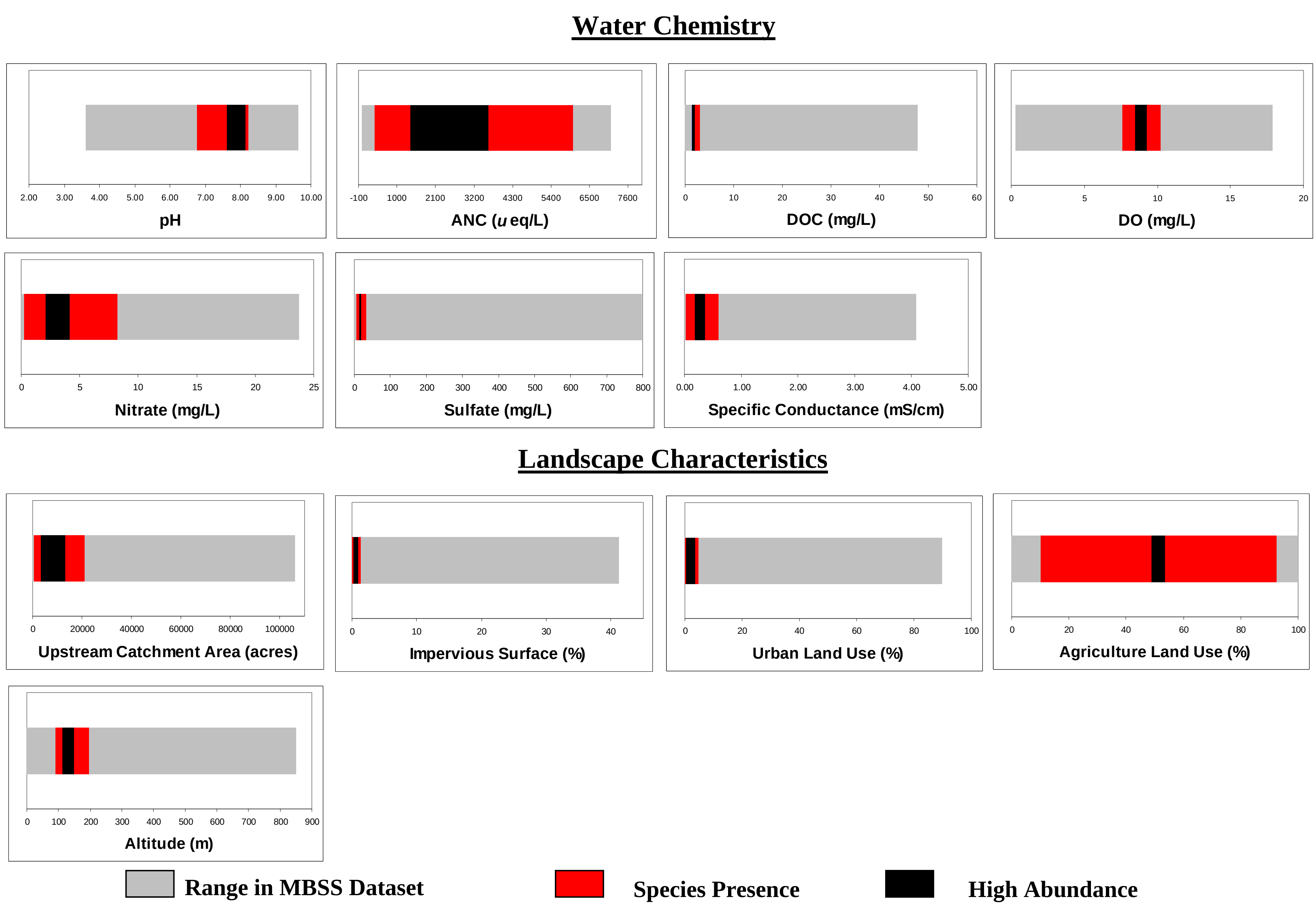


Fig. A-13: Checkered sculpin range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

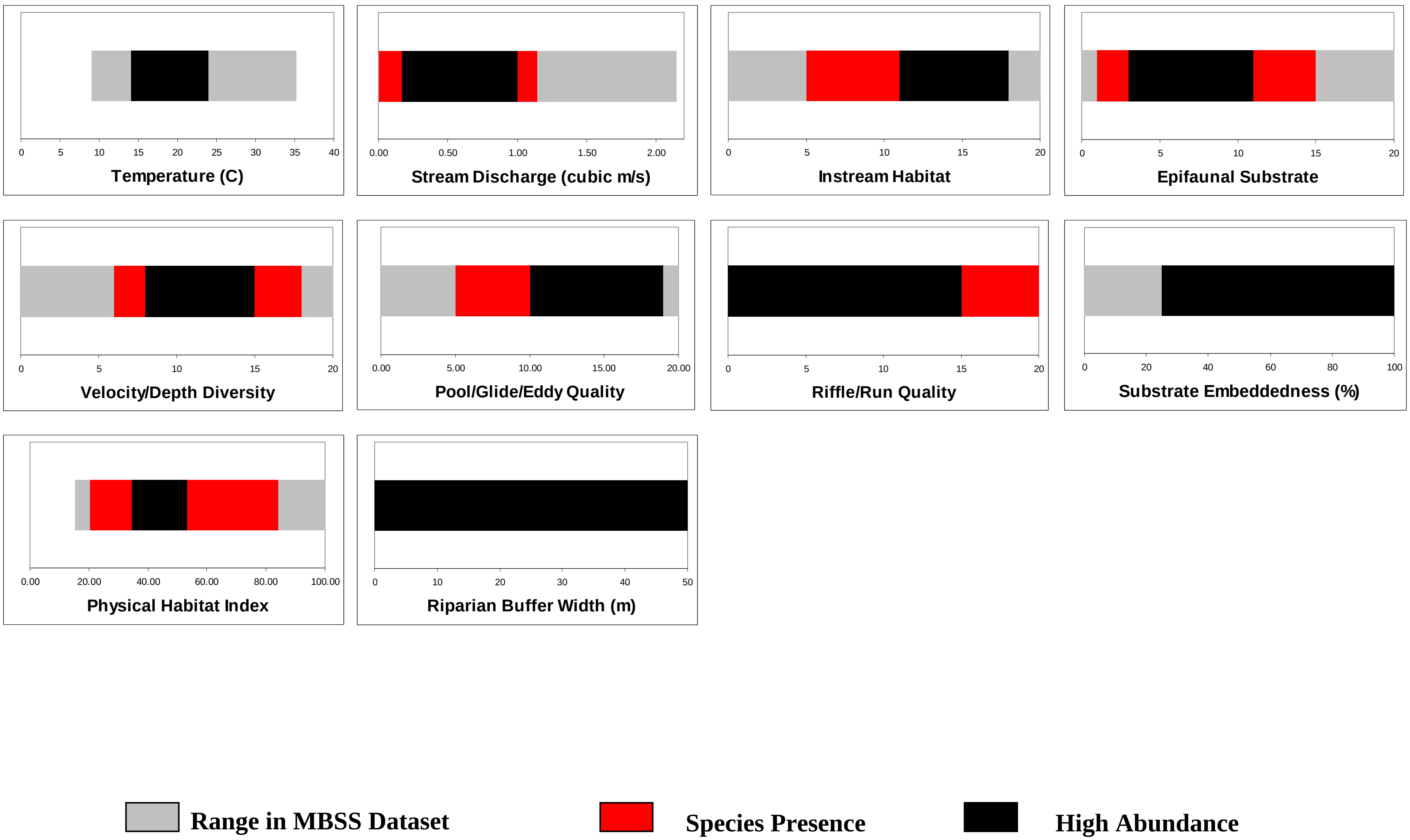


Fig. A-13: continued.

Comely shiner Illustration by: D.A. Neely
Notropis amoenus

Life History:

Adult Size: 50-75 mm SL (Lee et al. 1980; Jenkins and Burkhead 1994).

Longevity: unknown.

Diet: no data available.

Fecundity: unknown.

Spawning: Based on Virginia data, spawning most likely occurs from late-April to late-August. Spawning of this species has not been observed (Jenkins and Burkhead 1994).

Habitat: Comely shiner inhabits warm, moderate to low gradient streams and rivers. This species is typically associated with pool and slow water habitats adjacent to riffles or runs (Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: The distribution of comely shiner in Maryland is sporadic, with extant populations known from the Upper Potomac River, Middle Potomac River, Potomac Washington Metro, Lower Potomac River, Bush River, Patapsco River, Susquehanna River, and Choptank River drainage basins (Fig.A-14).

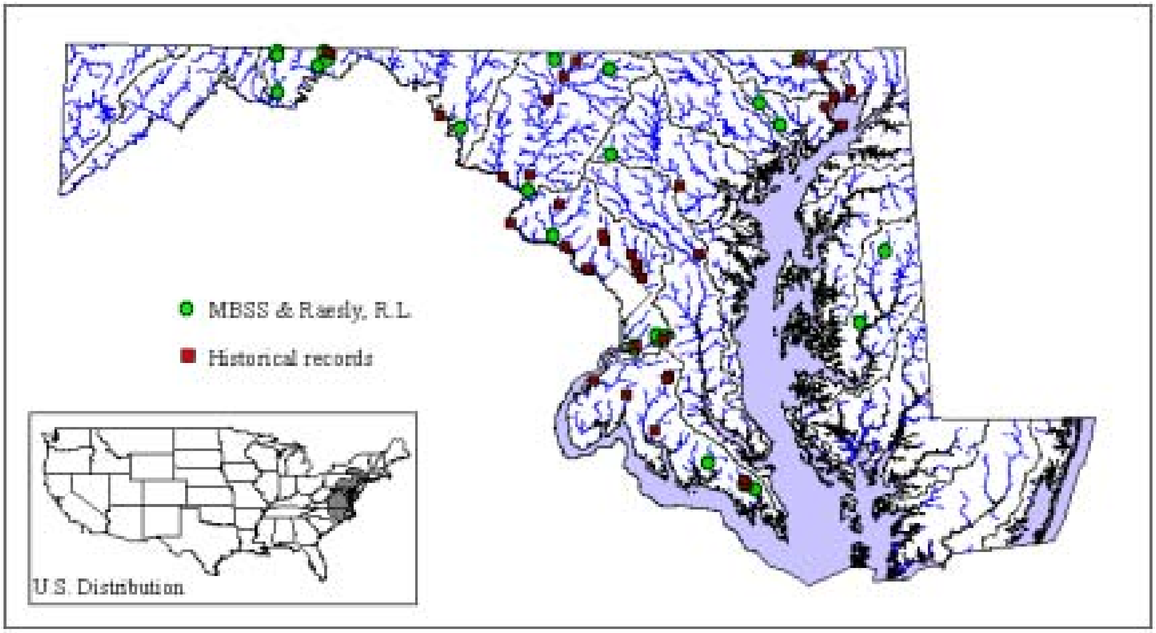


Fig. A-14. Records for comely shiner in Maryland.

Status and Abundance: Throughout its entire range, comely shiner is usually rare or uncommon, but is considered globally secure (Jenkins and Burkhead 1994). Comely shiner is a GCN species in Delaware. The status of this species, as determined by the Maryland Department of Natural Resources, is Threatened (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 13,053 ± 7,129 comely shiner in Maryland. Given its presence in mainstem rivers not sampled by MBSS, this is likely an underestimate of abundance.

Key Habitats: Comely shiner is associated with Highland, Piedmont, and Coastal Plain streams and large rivers (MDNR 2005). The stronghold watersheds for comely shiner include Piscataway Creek, Town Creek, Lower Winters Run, Sidling Hill Creek, and Atkisson Reservoir. These watersheds are essential for the conservation of comely shiner in Maryland.

Species Associations: A total of 60 different fish species were present at sites where comely shiner was collected. The five species that most often co-occurred with comely shiner included: redbreast sunfish, tessellated darter, American eel, pumpkinseed, and white sucker.

Stressors: Given the sporadic distribution of comely shiner in Maryland, stressors to this species vary by watershed. Populations of comely shiner in the Choptank River on Delmarva Peninsula are found within watersheds in which agriculture is the dominant land use. Adverse changes to streams associated with agriculture threaten the long-term viability of these populations. Three of the stronghold watersheds, Lower Winters Run, Atkisson Reservoir, and Piscataway Creek, have undergone extensive urbanization over the period 1973 to 2000 (Table A-1). Populations of comely shiner known from these watersheds are vulnerable to degradation of stream conditions associated with impervious surfaces. The other stronghold watersheds, Town Creek and Sidling Hill Creek, experienced a slight increase in urban land use during the same period. Continued urbanization and conversion of forested land for development will likely be detrimental to comely shiner populations in these watersheds in the future if left unmitigated. A list of other stressors in watersheds with comely shiner populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by comely shiner, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-15. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of comely shiner in Maryland requires the protection of critical habitats. Restoration and protection designed to sustain comely shiner populations should differ by watershed based on the dominant stressors to the populations at each locale. Management that aims to preserve or enhance the connectivity of critical comely shiner habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified comely shiner populations in sixteen 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, populations of comely shiner are known from mainstem, non-wadeable rivers not sampled by MBSS. Additional random sampling and targeted surveys within large rivers will improve our understanding of comely shiner abundance and the extent of comely shiner distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable comely shiner habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of this species. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of comely shiner populations and critical habitats.

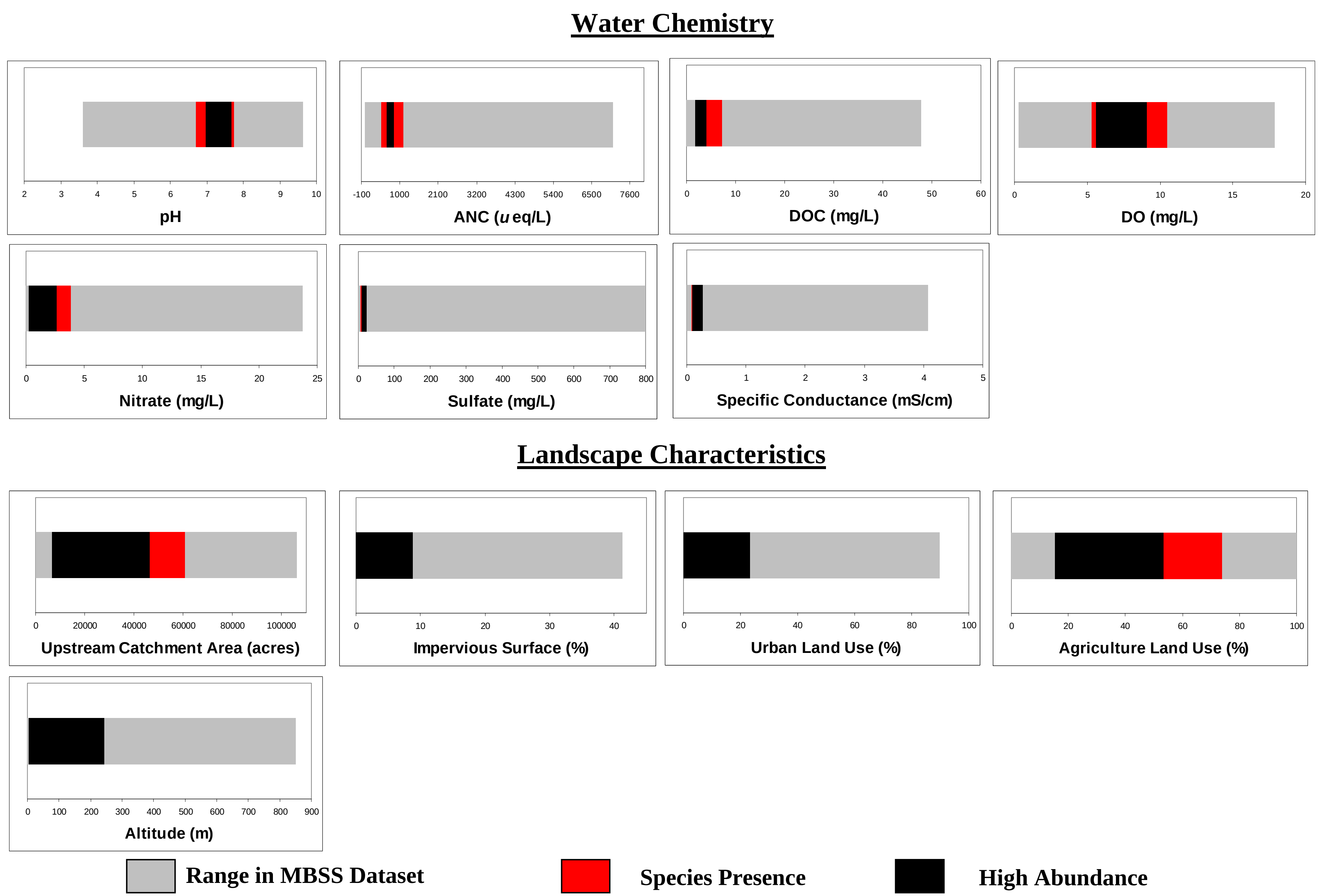


Fig. A-15: Comely shiner range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

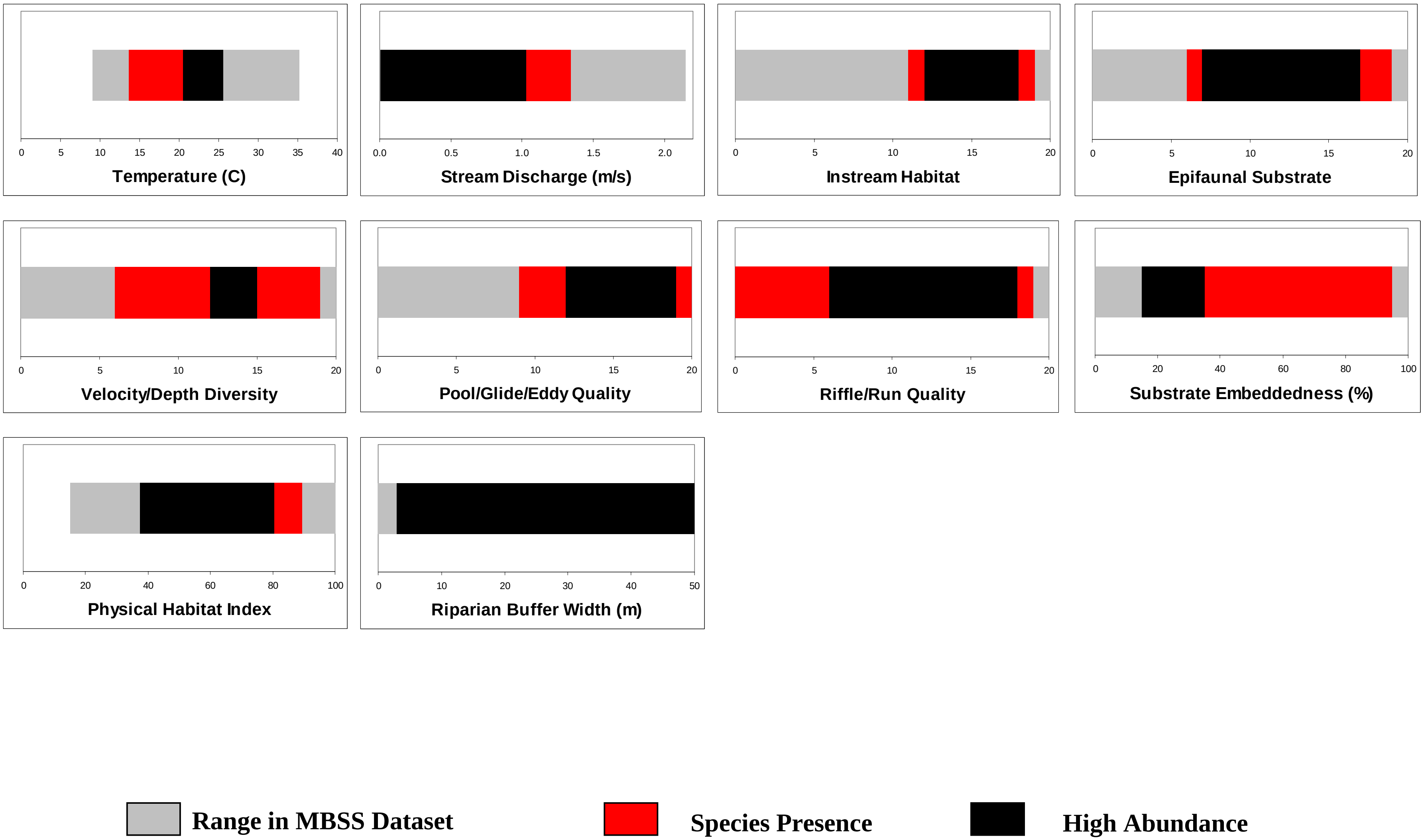


Fig. A-15: continued.

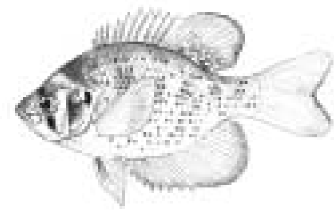


Illustration by: D.A. Neely

Flier
Centrarchus macropterus

Life History:

Adult Size: 70-250 mm TL (Schwartz 1961; Lee et al. 1980; Wujtewicz 1982; Jenkins and Burkhead 1994)

Longevity: 8 years (Schwartz 1961).

Diet: Small crustaceans, aquatic insects, small fishes, and algae (Flemer and Woolcott 1966; Jenkins and Burkhead 1994).

Fecundity: Females produce 1,900-37,500 eggs (Carlander 1977).

Spawning: Spawning occurs from March to May when water is 14-17 C. Adults congregate over nests (Carlander 1977; Jenkins and Burkhead 1994).

Habitat: Flier occupies ponds, lakes, swamps, and slow-moving pool habitats of streams and rivers (Jenkins and Burkhead 1994). This species is known to tolerate low pH waters and has been collected in salinity as high as 7 ppt.

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: The geographic distribution of flier in Maryland is confined to the Coastal Plain of the western shore of Chesapeake Bay. Extant populations of flier are known only from the Lower Potomac River drainage basin (Fig.A-16).

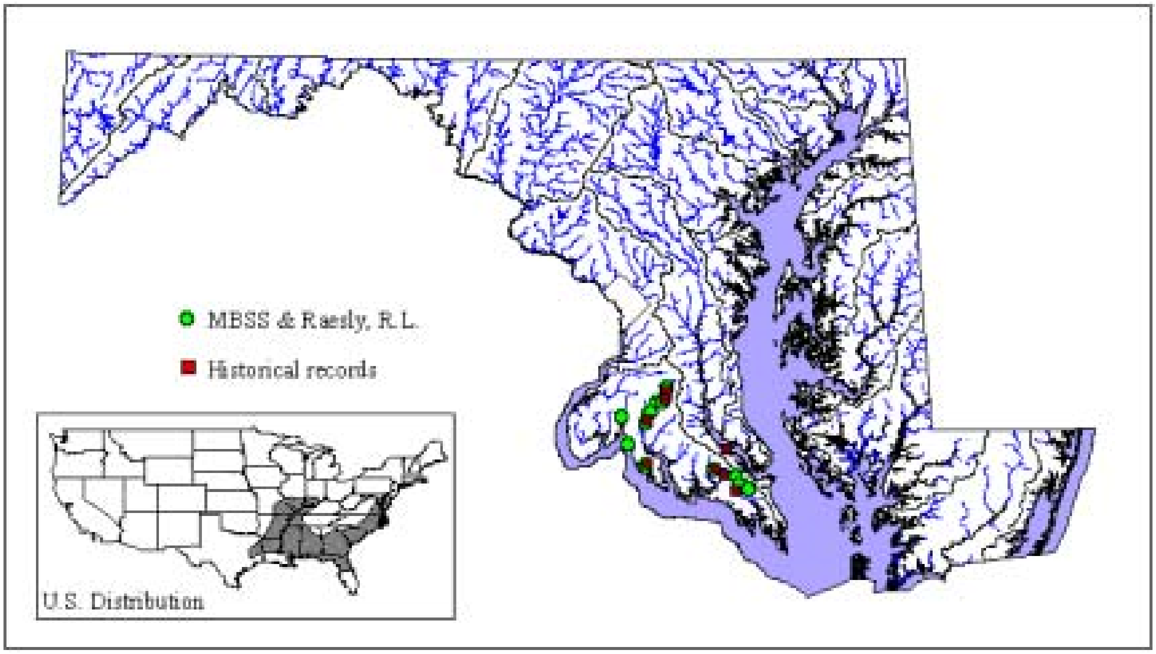


Fig. A-16. Records for flier in Maryland.

Status and Abundance: Flier is considered globally secure, but rare in parts of its range. The status of this species, as determined by the Maryland Department of Natural Resources, is Threatened (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 6,588 ± 5,197 flier in Maryland.

Key Habitats: Flier is associated with Blackwater and Coastal Plain streams (MDNR 2005). The stronghold watersheds for flier in Maryland are Potomac River Lower Tidal, Zekiah Swamp, Breton Bay, St. Mary's River, and Port Tobacco River. These watersheds are essential for the conservation of flier in Maryland.

Species Associations: A total of 32 different fish species were present at sites where flier was collected. The five species that most often co-occurred with flier included: eastern mudminnow, bluegill (a non-native species), American eel, pumpkinseed, and creek chubsucker.

Stressors: Flier populations in Maryland are located in predominately agricultural watersheds. Given its restricted distribution and propensity for swampy, slow water areas, this species is susceptible to stream degradation caused by anthropogenic stream channelization, nutrient over-enrichment, pesticide pollution, removal of riparian zones, and the application of lime may reduce or degrade the habitat preferred by this species. Urbanization has increased substantially, with a subsequent decrease in forested land, in each of the five stronghold watersheds for this species (Table A-1).

Stressors associated with urban development would be expected to have a negative effect on flier populations in these watersheds. Land use change, if continued, could ultimately degrade critical habitats and reduce populations of flier in these watersheds. A list of other stressors in watersheds with flier populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by flier, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-17. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of flier in Maryland requires the protection of critical habitats. Restoration of riparian buffers and the reduction (or full elimination) of stream channelization and management practices designed to limit nutrient and pesticide run-off will serve to protect these habitats. Management designed to limit impervious surface and reduce the negative effects of urbanization in stronghold watersheds will benefit populations of flier. Also, the preservation or enhancement of connectivity between flier populations via protection and restoration of critical habitats and the removal of stream blockages should be a management focus. Dissemination of information regarding known locations of flier populations to local jurisdictions will help ensure proper management of the stronghold watersheds. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified flier populations in five 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of flier abundance and the extent of flier distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable flier habitat that have not been previously sampled. Sampling in non-wadeable portions of river habitats may identify currently unknown populations of flier. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of flier populations and critical habitats.

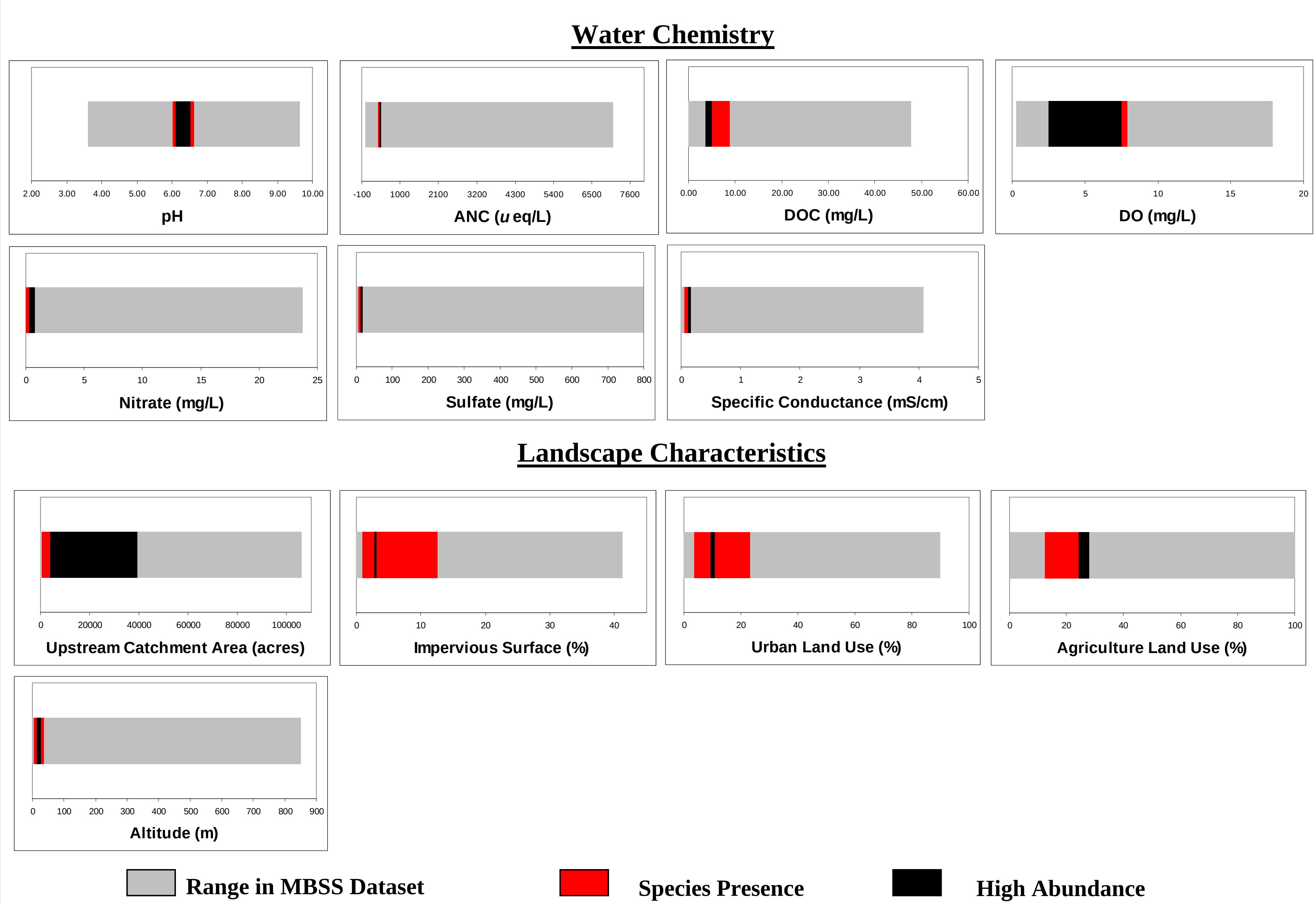


Fig. A-17: Flier range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

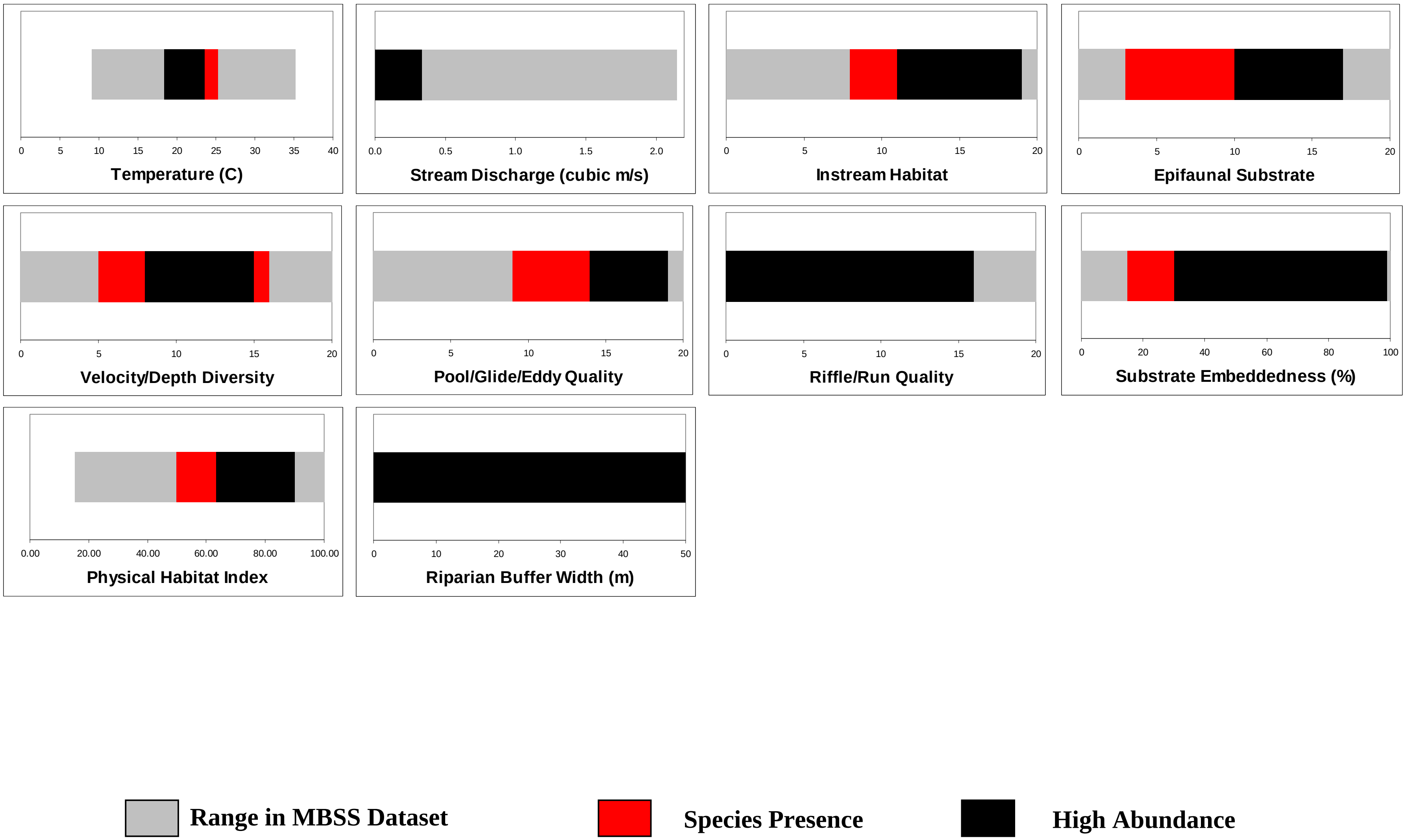


Fig. A-17: continued.

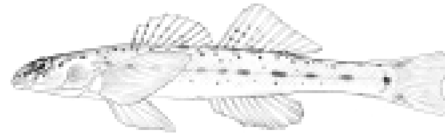


Illustration by: D.A. Neely

Glassy Darter
Etheostoma vitreum

<u>Life History:</u>

Adult Size: 30-55 mm SL, largest known specimen is 60mm SL from Virginia (Jenkins and Burkhead 1994; Lee et al. 1980).

Longevity: Adult stage reached within 1-2 years.

Diet: Primarily insectivorous (Jenkins and Burkhead 1994).

Fecundity: Females produce 68-223 eggs (Winn and Picciolo 1960).

Spawning: Spawning occurs from mid-March to mid-April in stream temperatures ranging from 10-19 ℃ in Maryland (Winn and Picciolo 1960). Glassy darter is a communal breeder; as many as 50 adults have been observed congregating over one spawning rock (Jenkins and Burkhead 1994). Spawning substrate consists of the top or underside of rocks or logs in strong current.

<u>Habitat:</u> Glassy darter inhabits sandy habitats in low to moderate gradient streams in the Piedmont and Coastal Plain provinces of Maryland. This species is most active at dusk and dawn, remaining partially buried in sand except when foraging (Jenkins and Burkhead 1994).

<u>Migration:</u> Unknown, but adults may make localized movements to preferred spawning habitats.

<u>Distribution and Abundance:</u>

Distribution: In Maryland, glassy darter occurs in the Patuxent River, Nanticoke River, and Pocomoke River drainage basins in the Coastal Plain of Maryland (Fig.A-18). Historically, glassy darter occurred in the Anacostia River watershed (Jenkins and Burkhead 1994), but this species was not collected there in recent surveys (MBSS 2004). There is one historic record in Winters Run, a northern tributary to West Chesapeake Bay (Lee et al. 1980). However, recent sampling efforts conducted by the MBSS (2004) of this and other watersheds draining the northern portions of West Chesapeake Bay suggest that glassy darter no longer occurs in this portion of the state. One specimen was collected from Morgan Run, a tributary to

Liberty Reservoir, of the Patapsco River basin (MBSS 2001). Further sampling in the watershed failed to locate additional specimens to confirm the existence of a viable population of glassy darter in the Patapsco River (Raesly and Kazyak 2004). The origin of the single specimen is unclear.

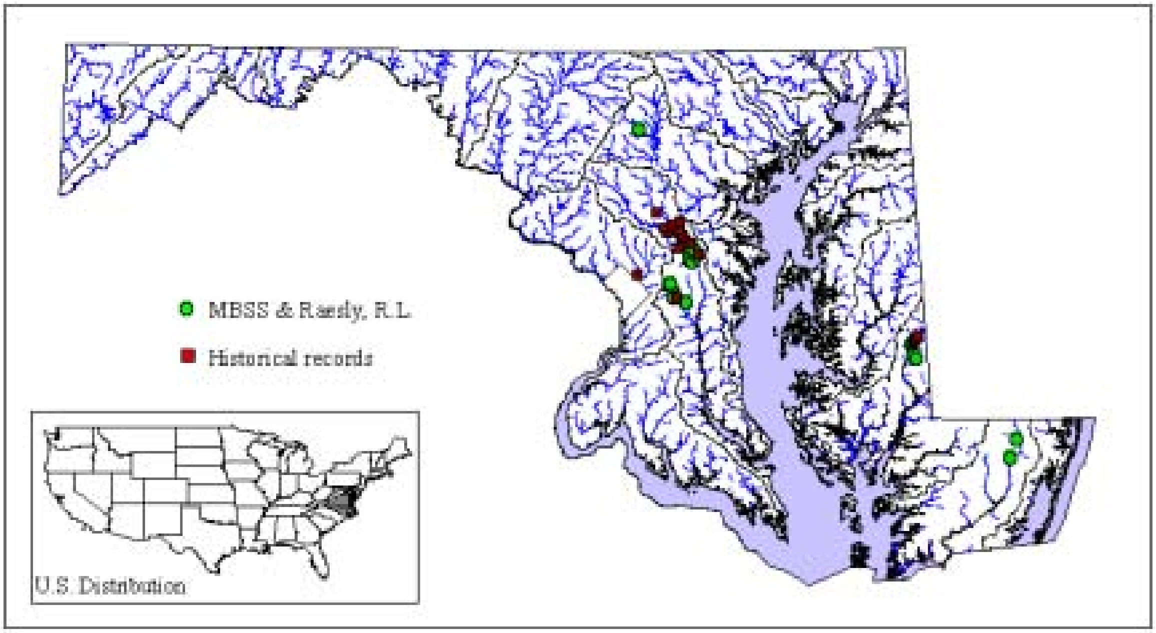


Fig. A-18. Records for glassy darter in Maryland.

Status and Abundance: Glassy darter is considered globally secure, but rare in parts of its range. Glassy darter is a GCN species in Delaware. The status of this species, as determined by the Maryland Department of Natural Resources, is Threatened (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 27,602 ± 23,244 glassy darter in Maryland.

Key Habitats: Glassy darter is associated with Coastal Plain streams (MDNR 2005). The stronghold watersheds for glassy darter include Little Patuxent River, Marshyhope Creek, Patuxent River Upper, Western Branch, and the Upper Pocomoke River. These watersheds are essential for the conservation of glassy darter in Maryland.

Species Associations: A total of 54 different fish species were present at sites where glassy darter was collected. The five species that most often co-occurred with glassy darter included: tessellated darter, American eel, redbreast sunfish, bluegill (non-native), and eastern mudminnow.

Stressors: Glassy darter is considered intolerant to anthropogenic stress (Roth et al. 1997). Given the distribution of glassy darter in urbanizing and agricultural watersheds in Maryland, stressors and threats to this species vary by watershed. The affinity of glassy darter for silt-free substrate for spawning lends this species vulnerable to excessive stream sedimentation commonly associated with landscape alteration. Populations of glassy darter in the Patuxent River drainage are located in watersheds undergoing extensive urbanization (Table A-1). The increase in urban land use coincided with a proportional loss of forested and agricultural lands. Based on the existing state of knowledge about adverse changes in stream temperature, stream water chemistry, stream velocity, and physical habitat quality associated with increasing urbanization, populations of glassy darter in the Patuxent River basin are likely declining. Populations known from the Nanticoke River and Pocomoke River are located in predominately agricultural watersheds. Adverse changes to streams associated with agriculture threaten the long-term viability of these populations. Marshyhope Creek and Upper Pocomoke River watersheds have undergone slight urbanization during the period from 1973 to 2000 (Table A-1). Land use change, if continued, could ultimately degrade critical habitats and reduce populations in these watersheds. A list of other stressors in watersheds with glassy darter populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by American brook lamprey, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-19. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of glassy darter in Maryland requires the protection of critical habitats. Restoration and protection designed to sustain glassy darter populations should differ by watershed based on the dominant stressors to the populations at each locale. Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of glassy darter in the Patuxent River drainage. Soil conservation and best management practices designed to limit channel alteration, stream bank erosion, and stream sedimentation will protect glassy darter spawning habitats. Management that aims to preserve or enhance the connectivity of these glassy darter habitats will also benefit this species. Additionally, dissemination of information regarding known locations of glassy darter populations to local jurisdictions will help ensure proper management of the stronghold watersheds. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified glassy darter populations in five 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of glassy darter abundance and the extent of glassy darter distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable glassy darter habitat that have not been previously sampled. Targeted sampling in these areas is also likely to identify currently unknown populations of glassy darter. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of glassy darter populations and critical habitats.

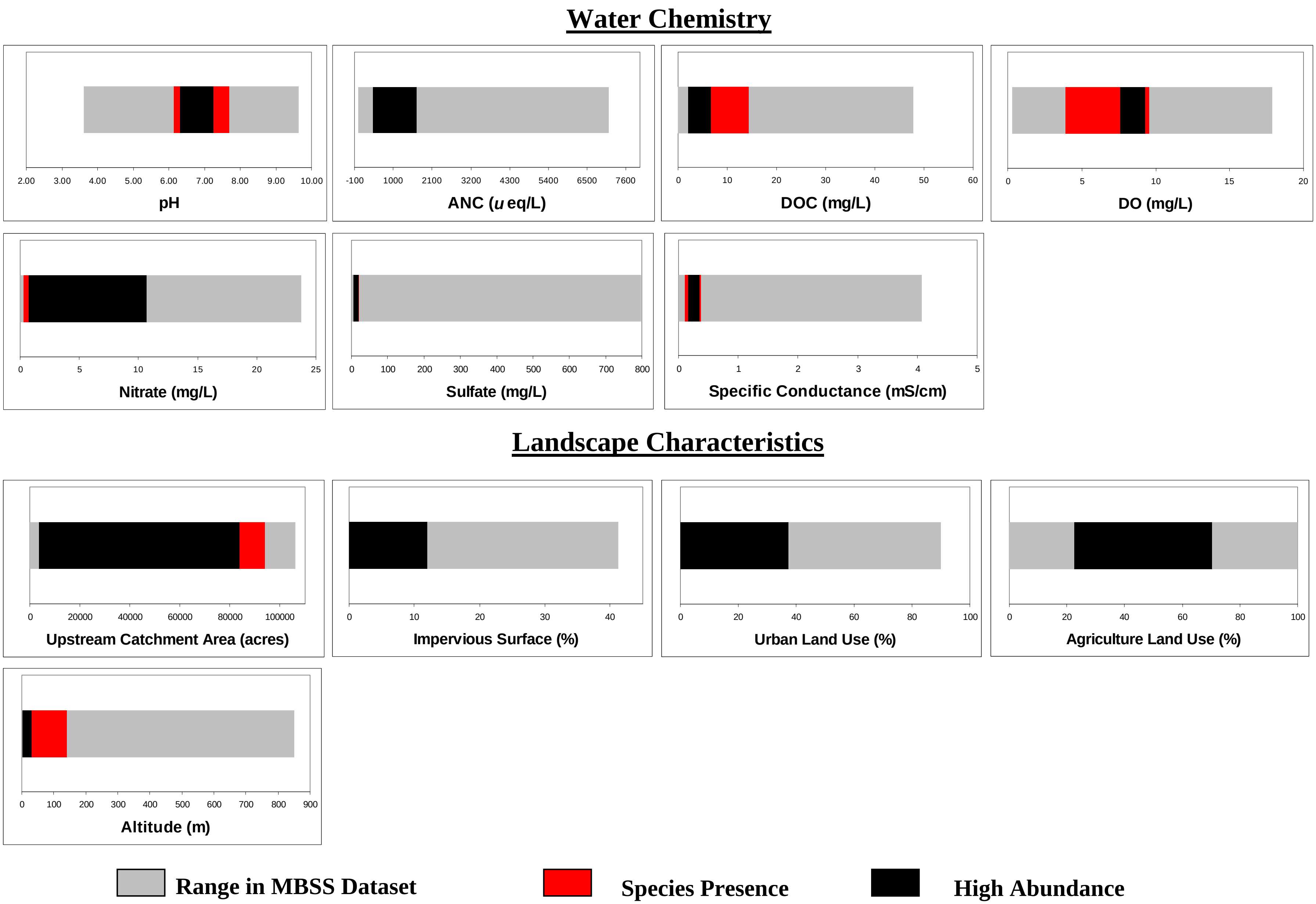
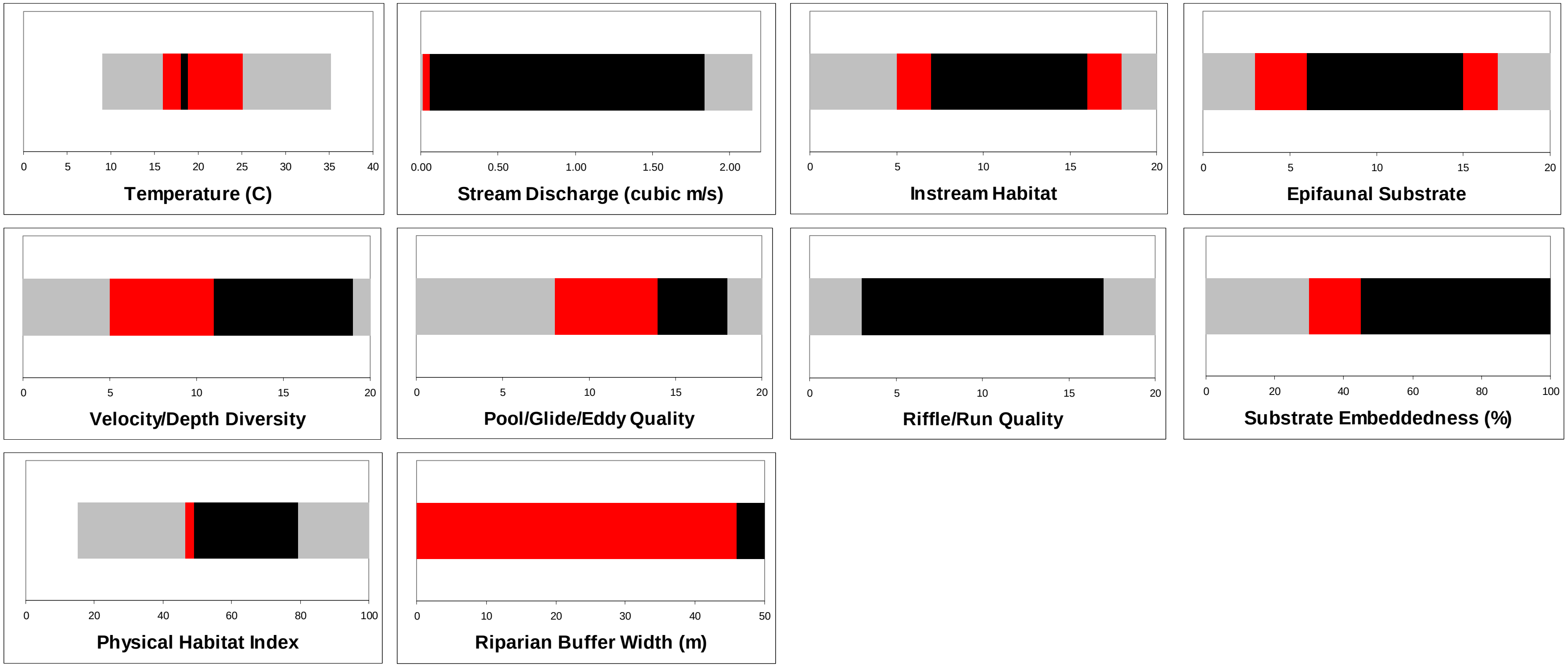


Fig. A-19: Glassy darter range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat



Range in MBSS Dataset **Species Presence** **High Abundance**

Fig. A-19: continued.

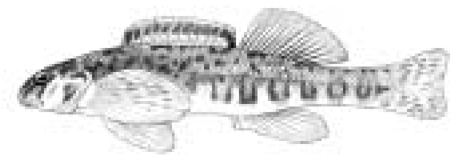


Illustration by: D.A. Neely

Greenside Darter
Etheostoma blennioides

Life History:

Adult Size: 54-75 mm SL (Lachner et al. 1950; Wolfe et al. 1978; Lee et al. 1980; Jenkins and Burkhead 1994).

Longevity: Maximum of 5 years (Jenkins and Burkhead 1994).

Diet: Insect larvae, small crustaceans, and snails (Turner 1921; Fahy 1954; Katula 1986; Jenkins and Burkhead 1994).

Fecundity: Females produce 400-2,000 eggs in one spawning season (Fahy 1954; Etnier and Starnes 1993; Jenkins and Burkhead 1994).

Spawning: Spawning occurs from late March to early May at temperatures above 13°C. (Lee et al. 1980; Jenkins and Burkhead 1994). The greenside darter is an egg-attacher, attaching eggs to vegetation, cobbles, and boulders. Spawning has also been reported over fine sand in areas without vegetation (Fahy 1954; Schwartz 1965b; Etnier and Starnes 1993; Jenkins and Burkhead 1994).

Habitat: Greenside darter inhabits moderate gradient, clear streams and rivers with course cobble and boulder substrate. This species is commonly found in riffle/run habitats and is often associated with vegetation (McCormick and Aspinwall 1983; Etnier and Starnes 1993; Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Extant populations of greenside darter are known from the Youghiogheny River, North Branch Potomac River, Upper Potomac River, Middle Potomac River, and the Potomac Washington Metro drainage basins (Fig.A-20).

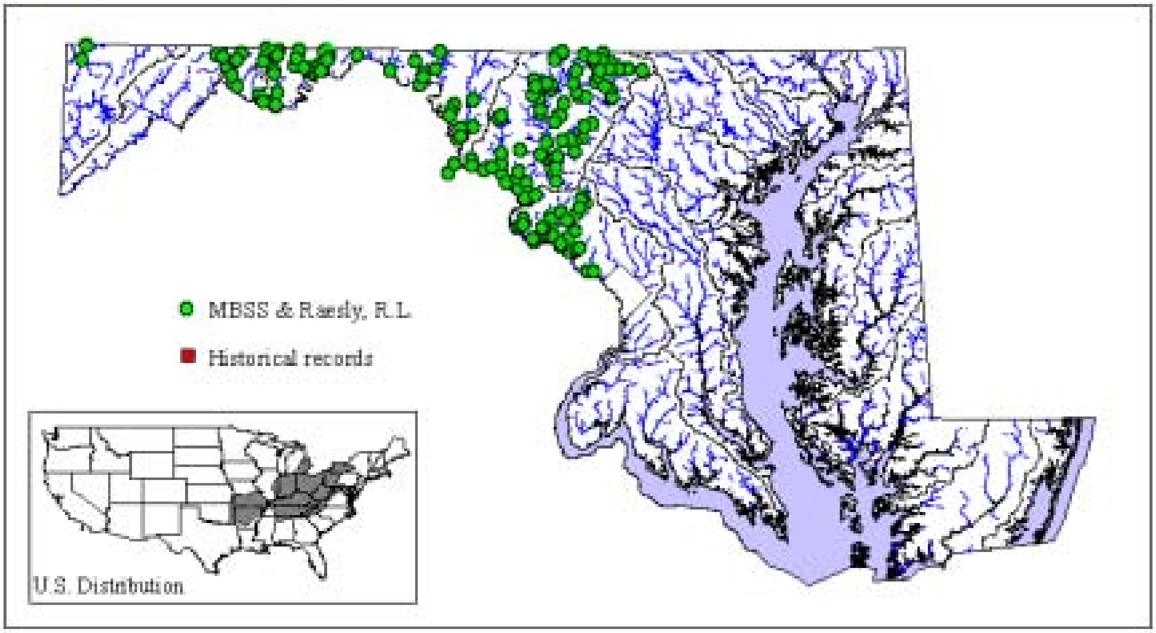


Fig. A-20. Records for greenside darter in Maryland.

Status and Abundance: Although it is not currently listed as a rare, threatened, or endangered species in Maryland, greenside darter has a restricted distribution in the state, making this species susceptible to human disturbance. Based on quantitative MBSS electrofishing data, there are currently an estimated 2,658,390 ± 4,767,241 greenside darter in Maryland.

Key Habitats: Greenside darter is associated with Highland and Piedmont streams (MDNR 2005). The stronghold watersheds for greenside darter include Sideling Hill Creek, Town Creek, Upper Monocacy River, Fifteen Mile Creek, and Double Pipe Creek. These watersheds are essential for the conservation of greenside darter in Maryland.

Species Associations: A total of 61 different fish species were present at sites where greenside darter was collected. The five species that most often co-occurred with greenside darter included: fantail darter, longnose dace, white sucker, bluntnose minnow, and blacknose dace.

Stressors: Given its restricted distribution and propensity for clear, cobble and boulder stream habitats, this species is susceptible to stream sedimentation and subsequent degradation caused by land use alteration. Two stronghold watersheds, Double Pipe Creek and Upper Monocacy, underwent substantial urbanization during the period of 1973 to 2000 (Table A-1). Adverse changes in stream conditions associated with urbanization are likely affecting populations of greenside darter in these watersheds. Sideling Hill Creek, Fifteen Mile Creek, and Town Creek watersheds have undergone slight urbanization during the same period. Continued urbanization and conversion of forested land for development will likely be detrimental to greenside darter populations in these watersheds in the future if left unmitigated. A list of other stressors in watersheds harboring greenside darter populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by greenside darter, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-21. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of greenside darter in Maryland requires the protection of critical habitats. Restoration of riparian buffers, as well as limits to and full mitigation of urbanization in the stronghold watersheds will help conserve current populations of this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified greenside darter populations in 23 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling will improve our understanding of greenside darter distribution and abundance, and track changes over time. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of greenside darter populations and critical habitats.

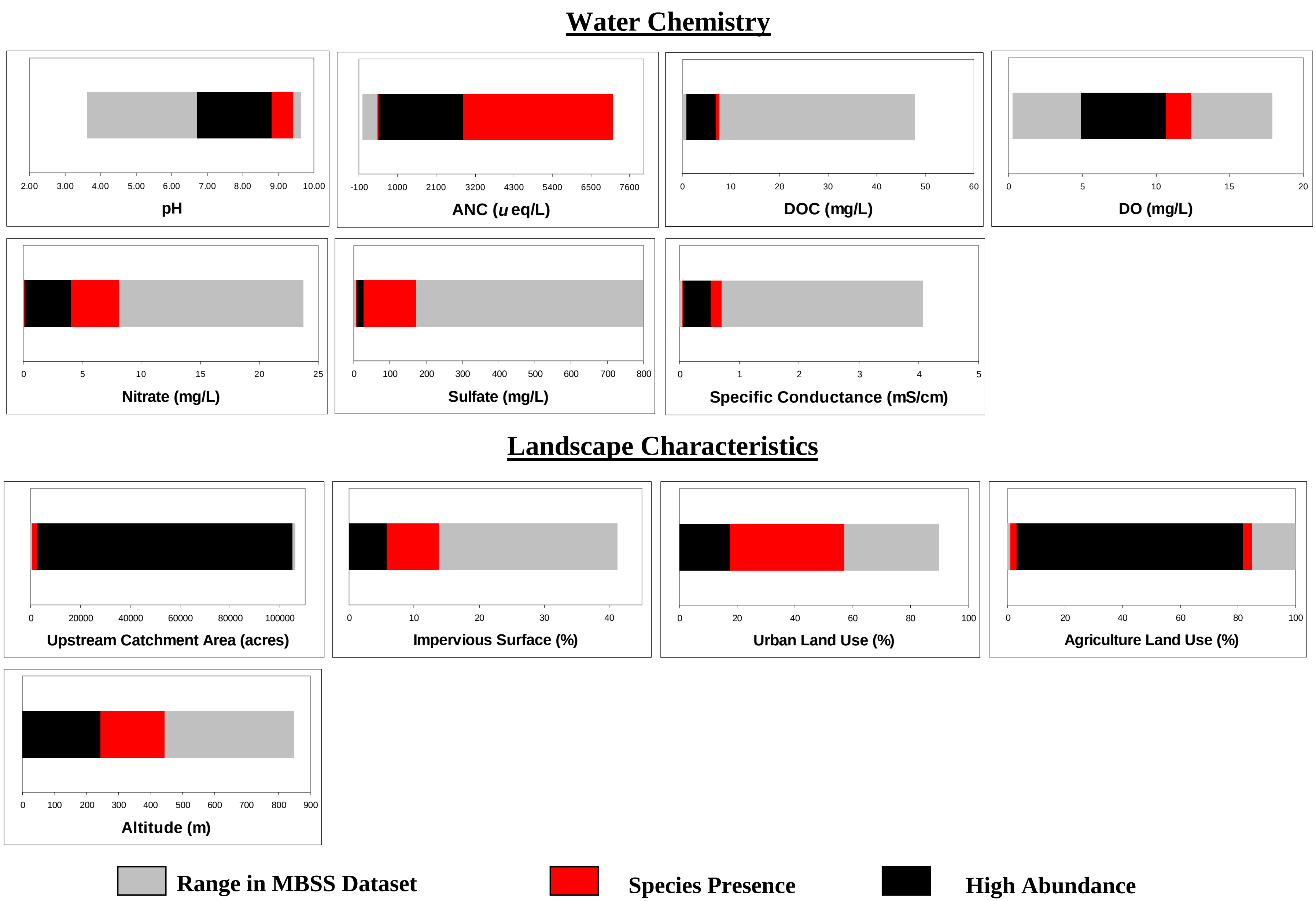


Fig. A-21: Greenside darter range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

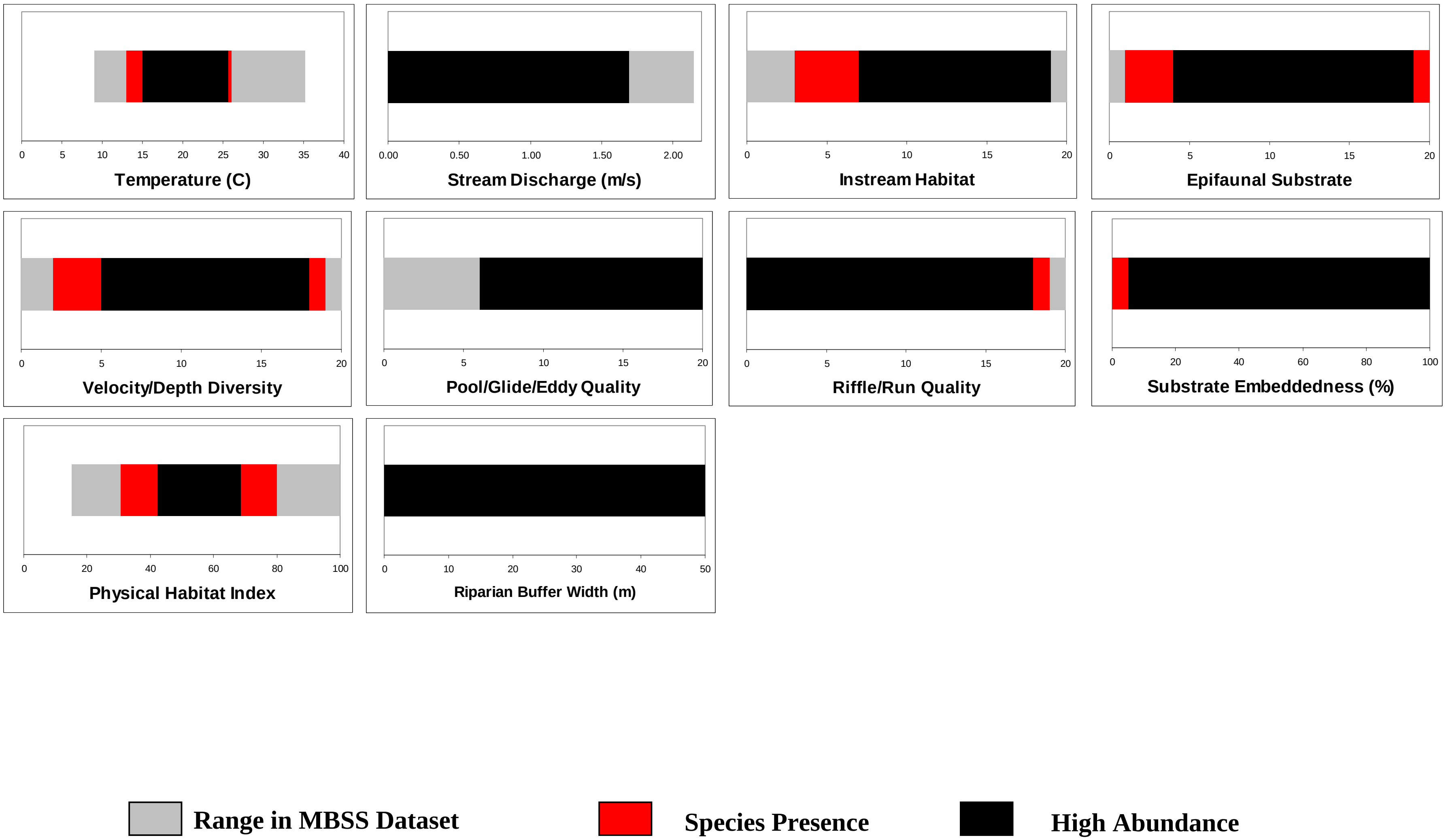
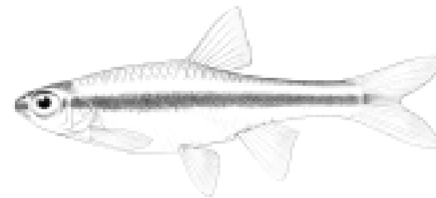


Fig. A-21: continued.



Ironcolor Shiner Illustration by: D.A. Neely
Notropis chalybaeus

Life History:

Adult Size: 24-55 mm SL (Jenkins and Burkhead 1994).

Longevity: Adult stage reached within 1-2 years.

Diet: Primarily insectivorous (Jenkins and Burkhead 1994).

Fecundity: 246 eggs from one mature female have been reported (Becker 1983).

Spawning: Spawning occurs from middle to late spring in Maryland (Wang and Kernehan 1979) in slow-flowing pools of the Coastal Plain. Fertilized eggs are broadcast and adhere to sand and other substrate (Jenkins and Burkhead 1994).

Habitat: Ironcolor shiner inhabits pool habitats in low gradient streams in the Coastal Plain of Maryland. This species has been collected in acidic blackwater streams on the Coastal Plain of western and eastern Chesapeake Bay.

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Historic records exist for Ironcolor shiner in the Susquehanna River near Havre de Grace and the Pocomoke River at Willards (MDNR Heritage data). However, extant populations are not known from these areas.. Wang and Kernehan (1979) reported ironcolor shiner populations in Delaware tributaries to Chester, Choptank, and Nanticoke Rivers. In Maryland, extant populations of the ironcolor shiner are known from portions of the Lower Potomac River drainage basin in the Coastal Plain of the Western shore of Chesapeake Bay, and the Choptank River basin located on Delmarva Peninsula (Fig.A-22).

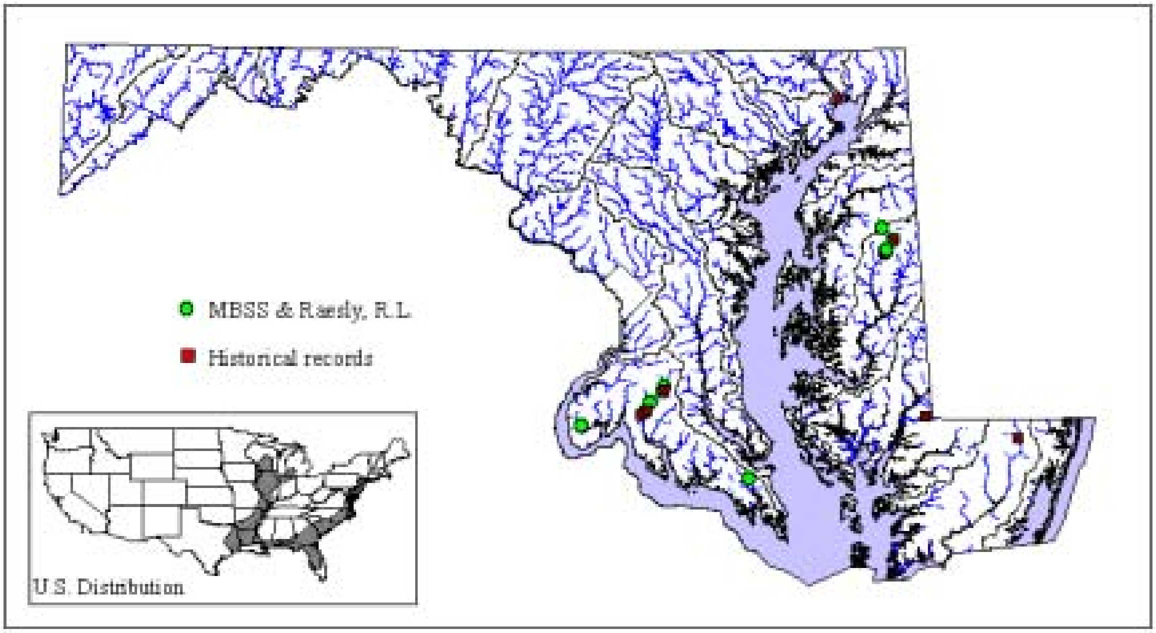


Fig. A-22. Records for ironcolor shiner in Maryland.

Status and Abundance: Although considered common in portions of its range, the distribution of ironcolor shiner in Maryland consists of small, disjunct populations. The status of this species, as determined by the Maryland Department of Natural Resources, is Endangered (COMAR 08.03.08). Ironcolor shiner is also a GCN species in Pennsylvania, Virginia, and Delaware. Based on quantitative MBSS electrofishing data, there are currently an estimated 4,800 ± 4,800 ironcolor shiner in Maryland.

Key Habitats: Ironcolor shiner is associated with Blackwater and Coastal Plain stream types (MDNR 2005). The stronghold watersheds for ironcolor shiner include Zekiah Swamp, Nanjemoy Creek, St. Mary's River, and Tuckahoe Creek. These watersheds are essential for the conservation of ironcolor shiner in Maryland.

Species Associations: A total of 32 different fish species were present at sites where ironcolor shiner was collected. The five species that most often co-occurred with ironcolor shiner included: pumpkinseed, eastern mudminnow, creek chubsucker, bluegill (non-native), and tessellated darter.

Stressors: Ironcolor shiner is considered intolerant to anthropogenic stress (Roth et al. 1997). The affinity of ironcolor shiner for silt-free substrate for spawning lends this species vulnerable to excessive stream sedimentation commonly associated with landscape alteration. Ironcolor shiner populations in Maryland are located in predominately agricultural watersheds. Practices associated with agriculture, such as stream channelization, application of fertilizers and pesticides, removal of riparian zones, and the application of lime may reduce or degrade the swampy, slow-water habitats preferred by this species. Urbanization has increased substantially in two stronghold watersheds for this species, St. Mary's River and Zekiah Swamp, followed by a proportional loss of agriculture and forested lands during the period from 1973 to 2000 (Table A-1). Stressors associated with urban development would be expected to have a negative effect on ironcolor shiner populations in these two watersheds. Tuckahoe Creek and Nanjemoy Creek watersheds experienced only slight increases in urban land use during the same 27-year period. Land use change, if continued, could ultimately degrade critical habitats and reduce populations in these watersheds. A list of other stressors in watersheds with ironcolor shiner populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by ironcolor shiner, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-23. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of ironcolor shiner in Maryland requires the protection of the silt-free spawning habitats preferred by this species. Soil conservation and best management practices designed to limit channel alteration, stream bank erosion, and stream sedimentation will protect populations of ironcolor shiner in agricultural watersheds. Restoration of riparian buffers, nutrient management, and the reduction (or full elimination) of stream channelization will serve to protect the swamp habitats preferred by this species. Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of ironcolor shiner in the Zekiah Swamp and St. Mary's River watersheds. Additionally, management that aims to preserve or enhance the connectivity of ironcolor shiner habitats will also benefit this species. A captive breeding program would also supplement re-establishment of ironcolor shiner into areas in which they have been extirpated. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified ironcolor shiner populations in four 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of ironcolor shiner abundance and the extent of ironcolor shiner distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable ironcolor shiner habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of ironcolor shiner. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of ironcolor shiner populations and critical habitats.

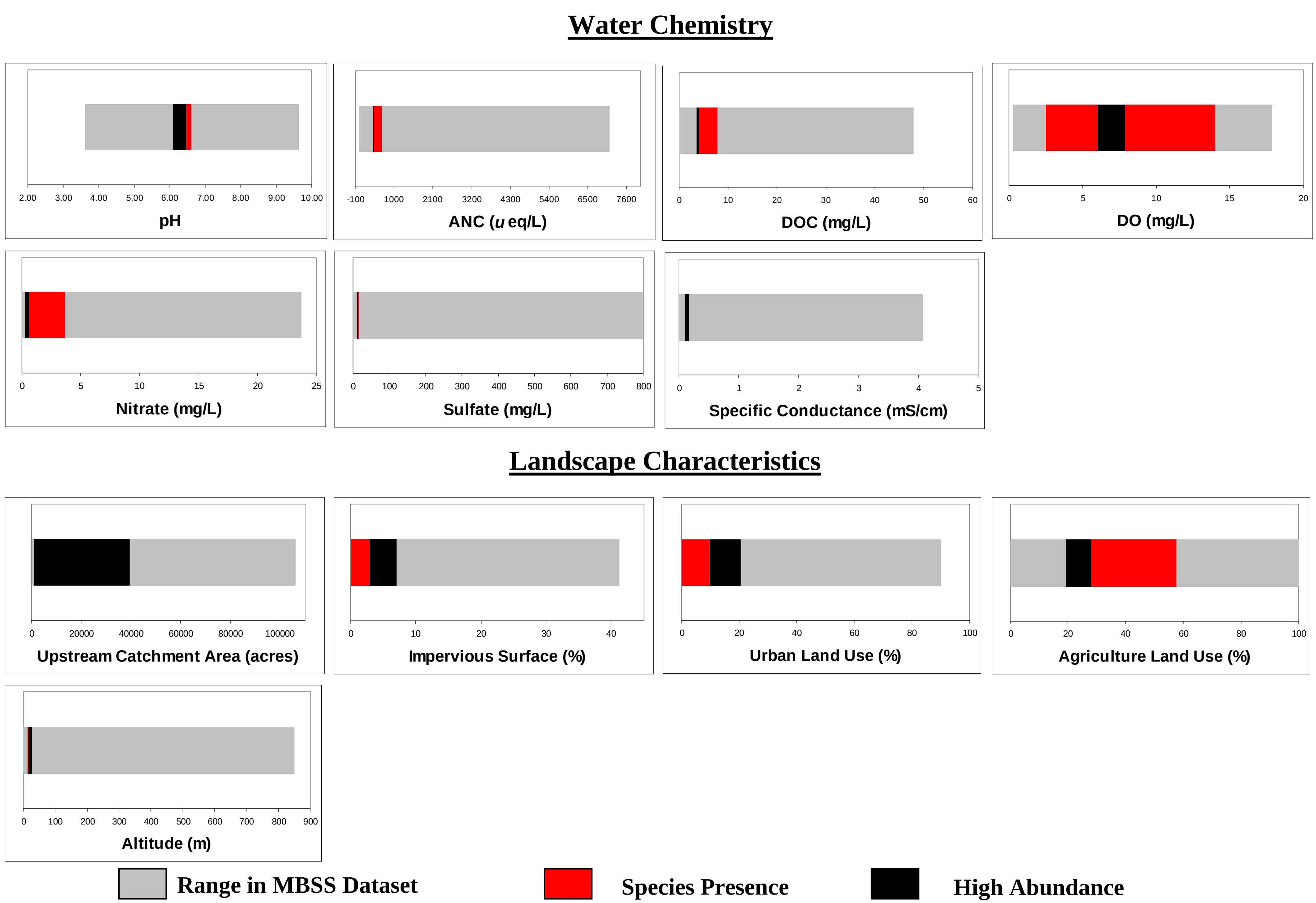


Fig. A-23: Ironcolor shiner range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

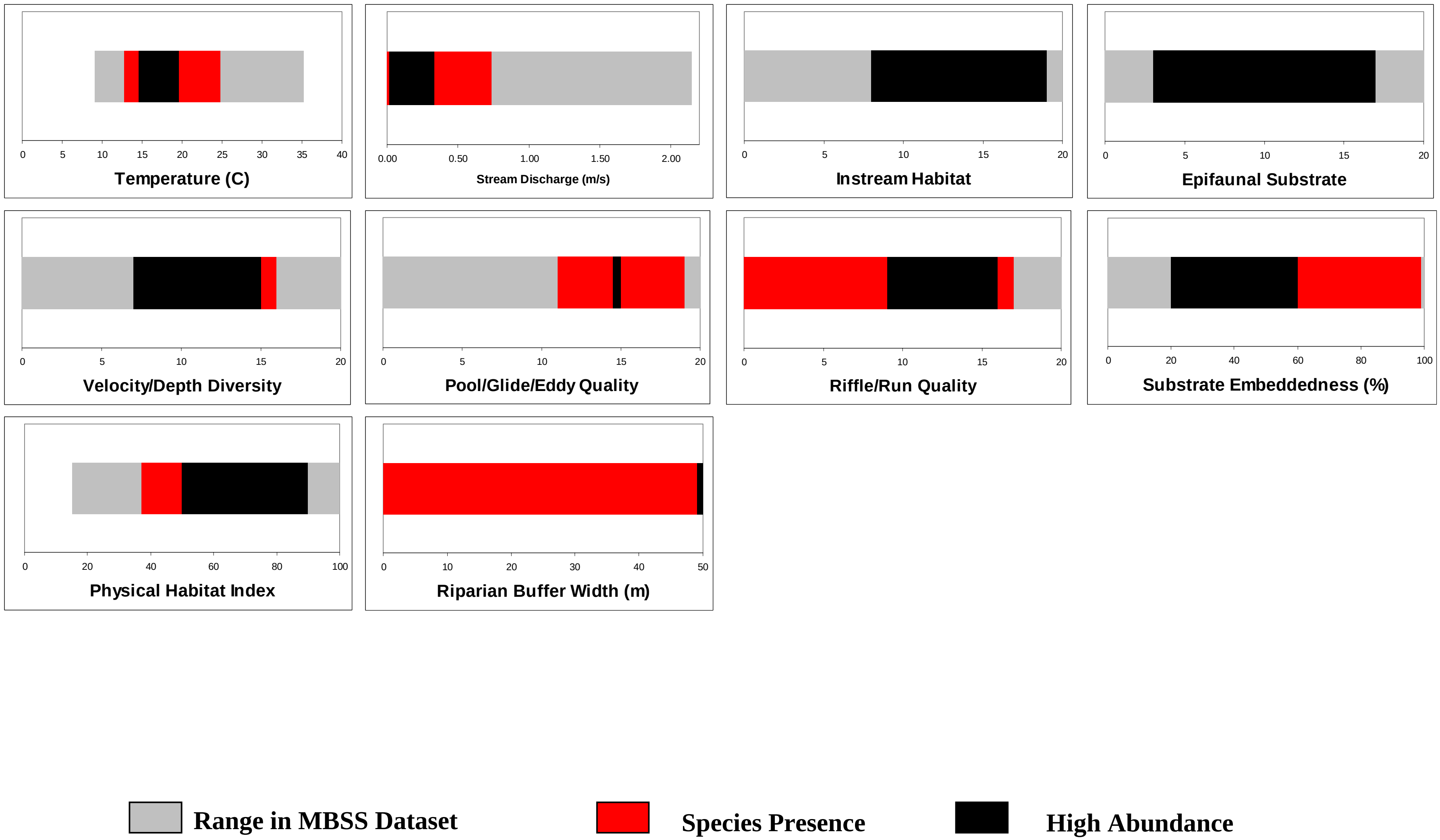
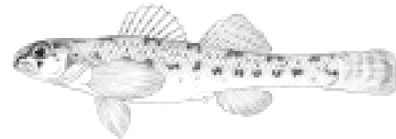


Fig. A-23: continued.



Johnny Darter Illustration by: D.A. Neely
Etheostoma nigrum

Life History:

Adult Size: 20-64 mm SL (Lee et al. 1980; Lutterbie 1979; Jenkins and Burkhead 1994).

Longevity: 2-4 years (Lutterbie 1979).

Diet: Primarily midge larvae, also small insects and other invertebrates (Turner 1921; Karr 1963; Roberts and Winn 1962; Jenkins and Burkhead 1994).

Fecundity: Females produce 40-200 eggs per spawning (Parrish et al. 1991; Etnier and Starnes 1993).

Spawning: Spawning occurs from mid-April to mid-June in areas north of Virginia (Parrish et al. 1991; Jenkins and Burkhead 1994). The johnny darter is an egg-attacher, inverting to attach eggs to the underside of cobbles, gravels, woody debris, and other hard substrates. Males guard eggs and clean eggs of silt (Etnier and Starnes 1993).

Habitat: Johnny darters inhabit warm, moderate gradient streams and rivers with rock, gravel, sand, and silt substrates. This species is commonly found in pool or slow run habitats and is sometimes associated with vegetation (Paine et al. 1982; Etnier and Starnes 1993; Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: In Maryland, johnny darter is confined in distribution to the Youghiogheny drainage of western Maryland (Fig.A-24). No populations of johnny darter are known from the Atlantic slope drainage in Maryland.

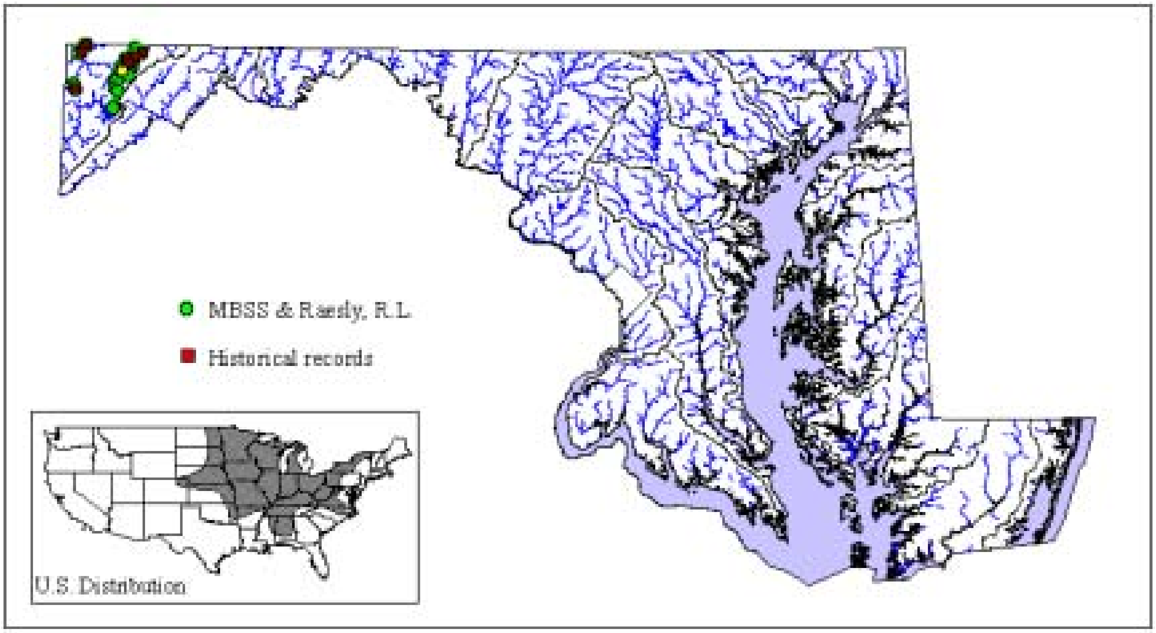


Fig. A-24. Records for johnny darter in Maryland.

Status and Abundance: Johnny darter is considered globally secure, but rare in parts of its range. The johnny darter is currently on the Maryland state "Watch List". Based on quantitative MBSS electrofishing data, there are currently an estimated 31,958 ± 16,142 johnny darter in Maryland.

Key Habitats: Johnny darter is associated with the Highland streams (MDNR 2005). The stronghold watersheds for johnny darter include the Casselman River, Deep Creek Lake, and the Youghiogheny River. These watersheds are essential for the conservation of johnny darter in Maryland.

Species Associations: A total of 33 different fish species were present at sites where johnny darter was collected. The five species that most often co-occurred with johnny darter included: creek chub, white sucker, blacknose dace, mottled sculpin, and rock bass.

Stressors: Johnny darter populations are restricted to the Youghiogheny River basin in Western Maryland. This restricted population makes this species vulnerable to human disturbance within this basin. Urbanization has increased substantially in the Deep Creek Lake watershed, a stronghold for this species, followed by a proportional loss of agriculture and forested lands during the period from 1973 to 2000 (Table A-1). Stressors associated with urban development would be expected to have a negative effect on johnny darter populations in this watershed. The Casselman River and Youghiogheny River watersheds experienced only slight increases in urban land use during the same 27-year period. Land use change, if continued, could ultimately degrade critical habitats and reduce populations in these watersheds. Sedimentation caused by logging, and changes in water chemistry associated with acid mine drainage are stressors to johnny darter populations. A list of other stressors in watersheds with johnny darter populations is shown in Appendix B. The ranges of chemical and physical conditions at sites occupied by johnny darter, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-25. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of johnny darter in Maryland requires full mitigation of logging practices and acid mine drainage within the Youghiogheny watershed. Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of johnny darter in the Deep Creek Lake watershed. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified johnny darter populations in three 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of johnny darter abundance and the extent of johnny darter distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable johnny darter habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of johnny darter. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of johnny darter populations and critical habitats.

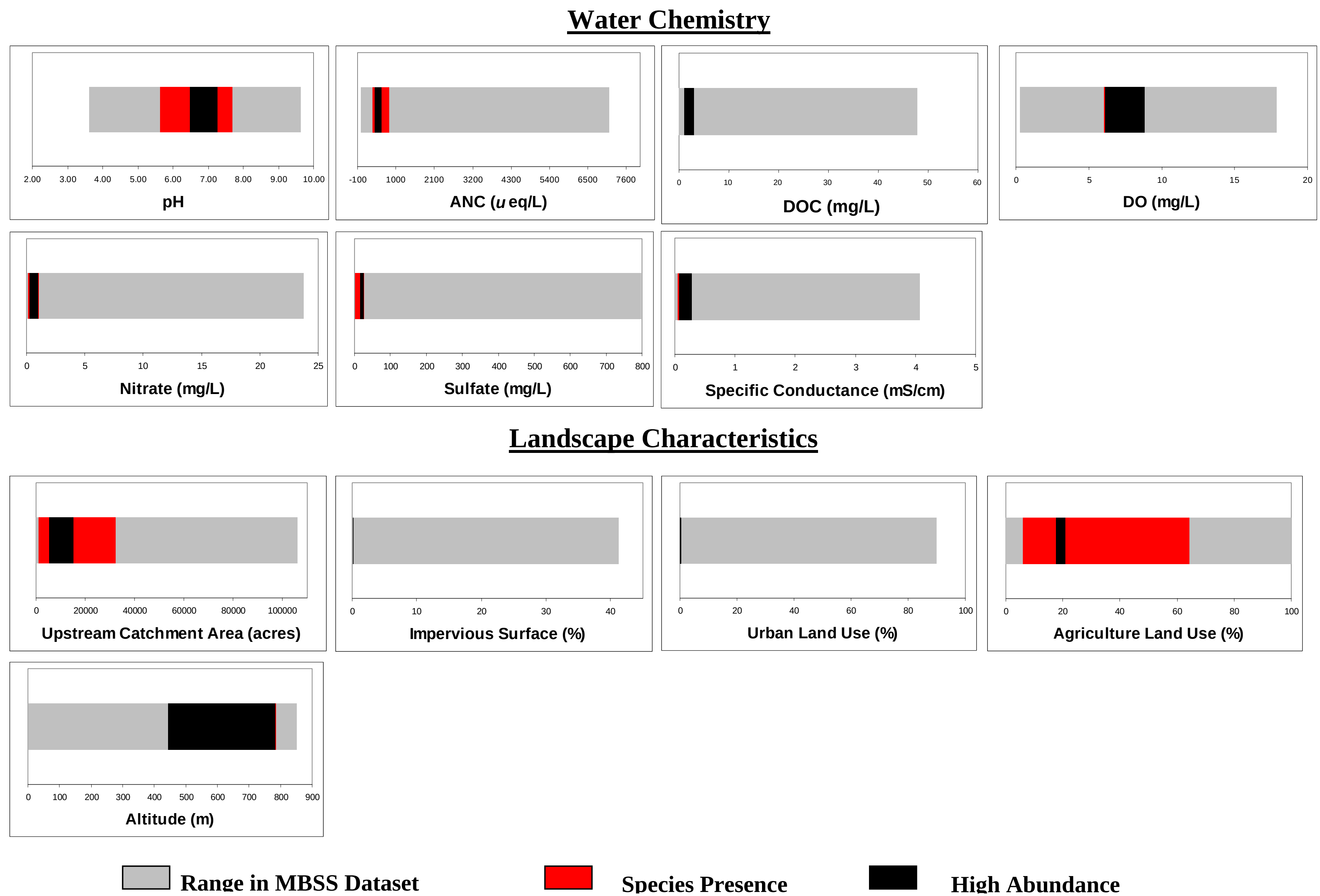


Fig. A-25: Johnny darter range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

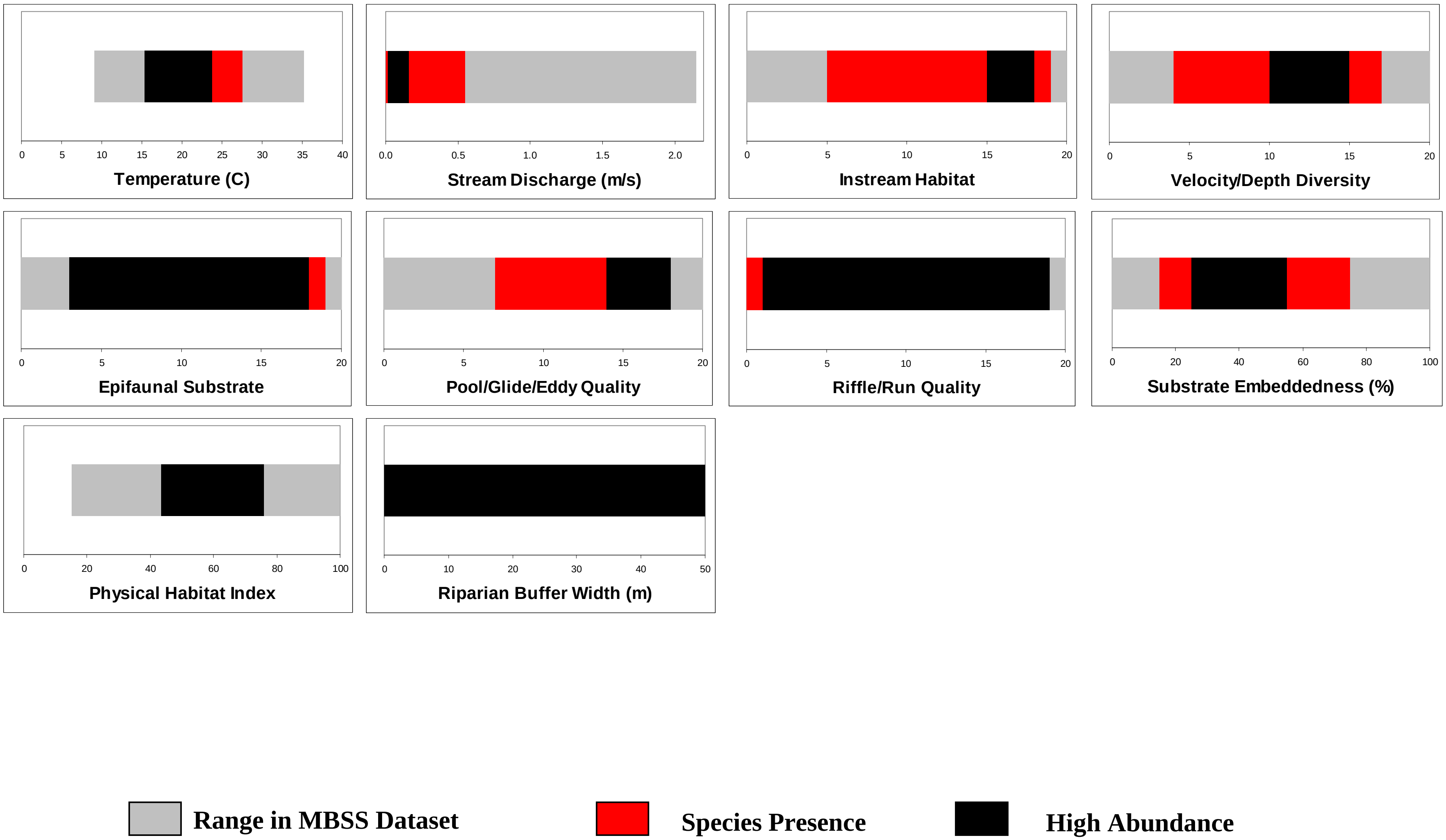
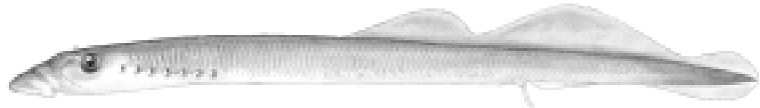


Fig. A-25: continued.



Least brook lamprey Illustration by: D.A. Neely
Lampetra aepyptera

Life History:

Adult Size: 90-151 mm TL (Seversmith 1953; Lee et al. 1980).

Longevity: Larval stage spans 5-6 years. Metamorphosis occurs in late summer or early fall. Adults spawn in spring of the following year. Death of adults occurs after spawning is complete (Rohde et al.1976; Jenkins and Burkhead 1994).

Diet: Ammocoetes feed on plankton and detritus; adults do not feed (Jenkins and Burkhead 1994).

Fecundity: Females produce 572-3,816 eggs (Seversmith 1953; Holbrook 1975; Rohde et al. 1976; Walsh and Burr 1981; Jenkins and Burkhead 1994).

Spawning: Least brook lampreys spawn from mid-March to mid-May in Maryland (Seversmith 1953). Spawning occurs in pool and riffle transition areas over sand and gravel (Jenkins and Burkhead 1994). Males construct nests that consist of loose gravel surrounding a pit of sand substrate. Spawning may occur between single pairs, or may be communal with multiple males and a single female (Etnier and Starnes 1993).

Habitat: Least brook lamprey inhabit slow, low gradient, warmwater streams with sand, gravel, and silt substrates (Jenkins and Burkhead 1994). Ammocoetes commonly occupy the soft sediments of pool habitats (Seversmith 1953).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: In Maryland, the least brook lamprey is found in the Potomac Washington Metro, Lower Potomac River, Patuxent River, West Chesapeake Bay, Patapsco River, Gunpowder River, Bush River, and Elk River drainage basins of the Coastal Plain of the Western shore of Chesapeake Bay, and the Chester River, Choptank River, Nanticoke/Wicomico River and the Pocomoke River drainage basins on Delmarva Peninsula (Fig.A-26).

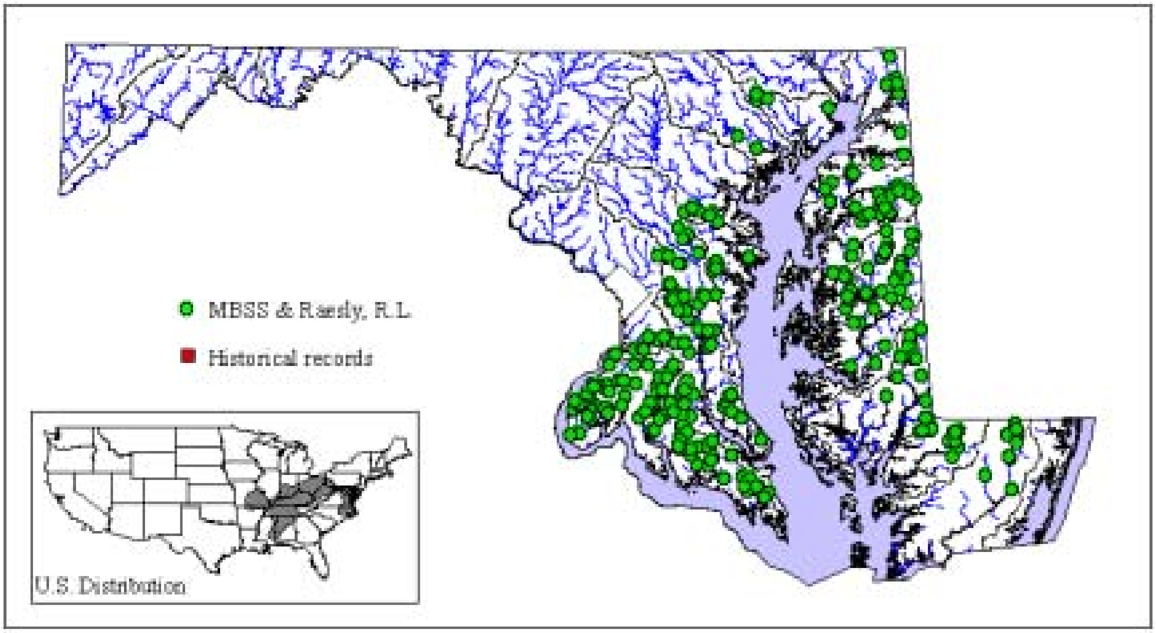


Fig. A-26. Records for least brook lamprey in Maryland.

Status and Abundance: Although not currently listed as rare, threatened, or endangered in Maryland, the least brook lamprey is considered intolerant to anthropogenic stress (Roth et al. 1997). Least brook lamprey is also a GCN species in Virginia. Based on quantitative MBSS electrofishing data, there are currently an estimated 1,218,016 ± 444,019 least brook lamprey in Maryland.

Key Habitats: Least brook lamprey is associated with Blackwater and Coastal Plain streams (MDNR 2005). The stronghold watersheds for least brook lamprey include Potomac River Middle Tidal, Wye River, St. Clements Bay, Zekiah Swamp, and Upper Chester River. These watersheds are essential for the conservation of least brook lamprey in Maryland.

Species Associations: A total of 64 different fish species were present at sites where least brook lamprey was collected. The five species that most often co-occurred with least brook lamprey included: American eel, eastern mudminnow, tessellated darter, pumpkinseed, and creek chubsucker.

Stressors: Given the large distribution of least brook lamprey in the Coastal Plain of Maryland, stressors to this species vary by watershed. Adverse changes to stream conditions associated with poor agricultural practices and urbanization may reduce the habitats preferred by least brook lamprey. The removal of forested land associated with urbanization and agriculture has reduced or eliminated populations of least brook lamprey in areas of Maryland (Stranko et al. 2005). Urban land use increased substantially in two least brook lamprey stronghold watersheds, Zekiah Swamp and Wye River, over the period 1973 to 2000 (Table A-1). Slight increases in urban land use occurred in each of the other stronghold watersheds during the same period. Continued urbanization and conversion of forested land for development will likely be detrimental to least brook lamprey populations in these watersheds in the future if left unmitigated. A list of other stressors in watersheds with least brook lamprey populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by least brook lamprey, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-27. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of least brook lamprey in Maryland requires the protection of critical habitats. Restoration and protection designed to sustain least brook lamprey populations should differ by watershed based on the dominant stressors to the populations at each locale. Restoration of riparian buffers and the establishment of best management practices for minimizing the adverse effects of agriculture will serve to protect critical habitats. Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of least brook lamprey in Zekiah Swamp and Wye River watersheds. Management that aims to preserve or enhance the connectivity of critical least brook lamprey habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified least brook lamprey populations in 50 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling will improve our understanding of least brook lamprey distribution and abundance, and track changes over time. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of least brook lamprey populations and critical habitats.

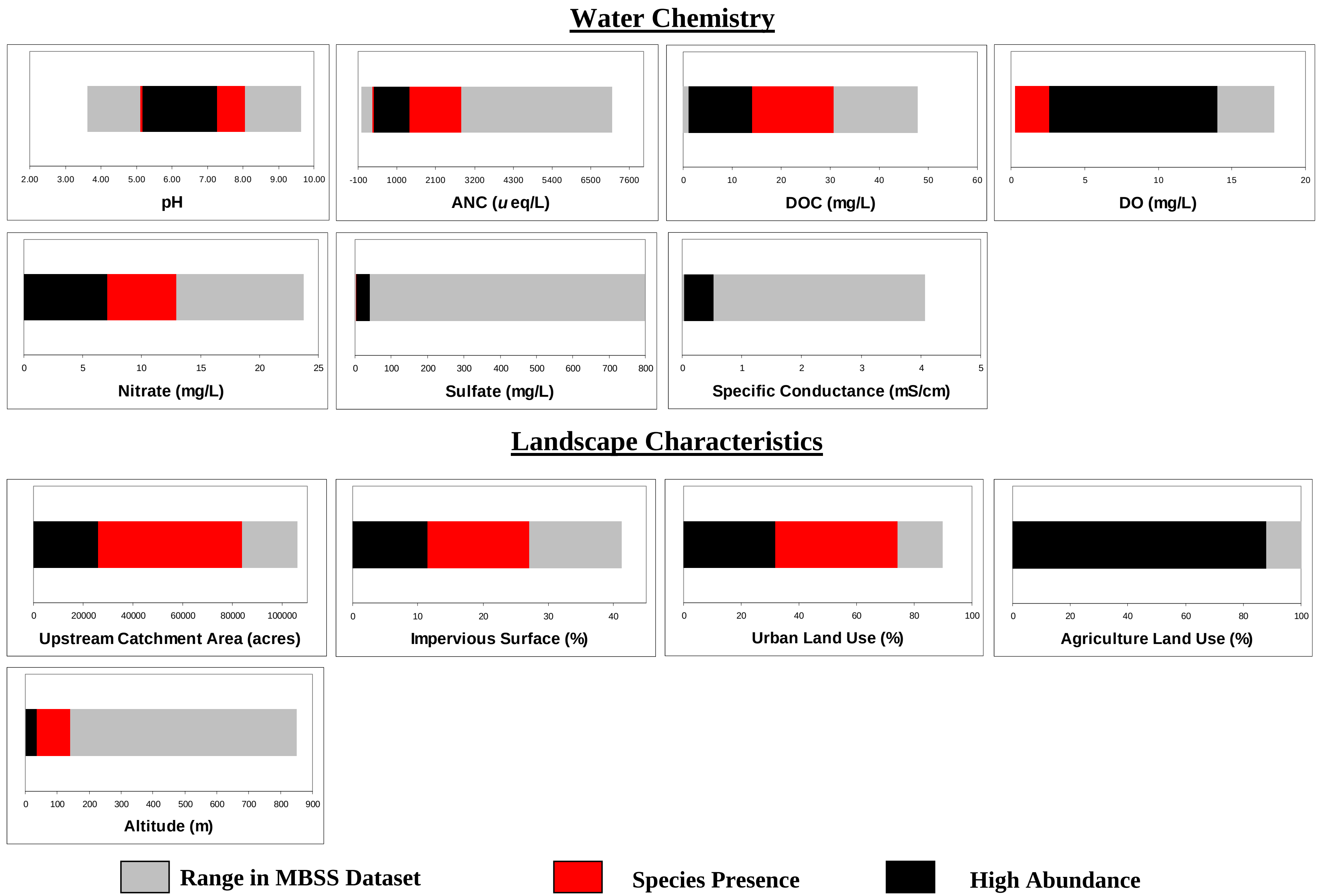


Fig. A-27: Least brook lamprey range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

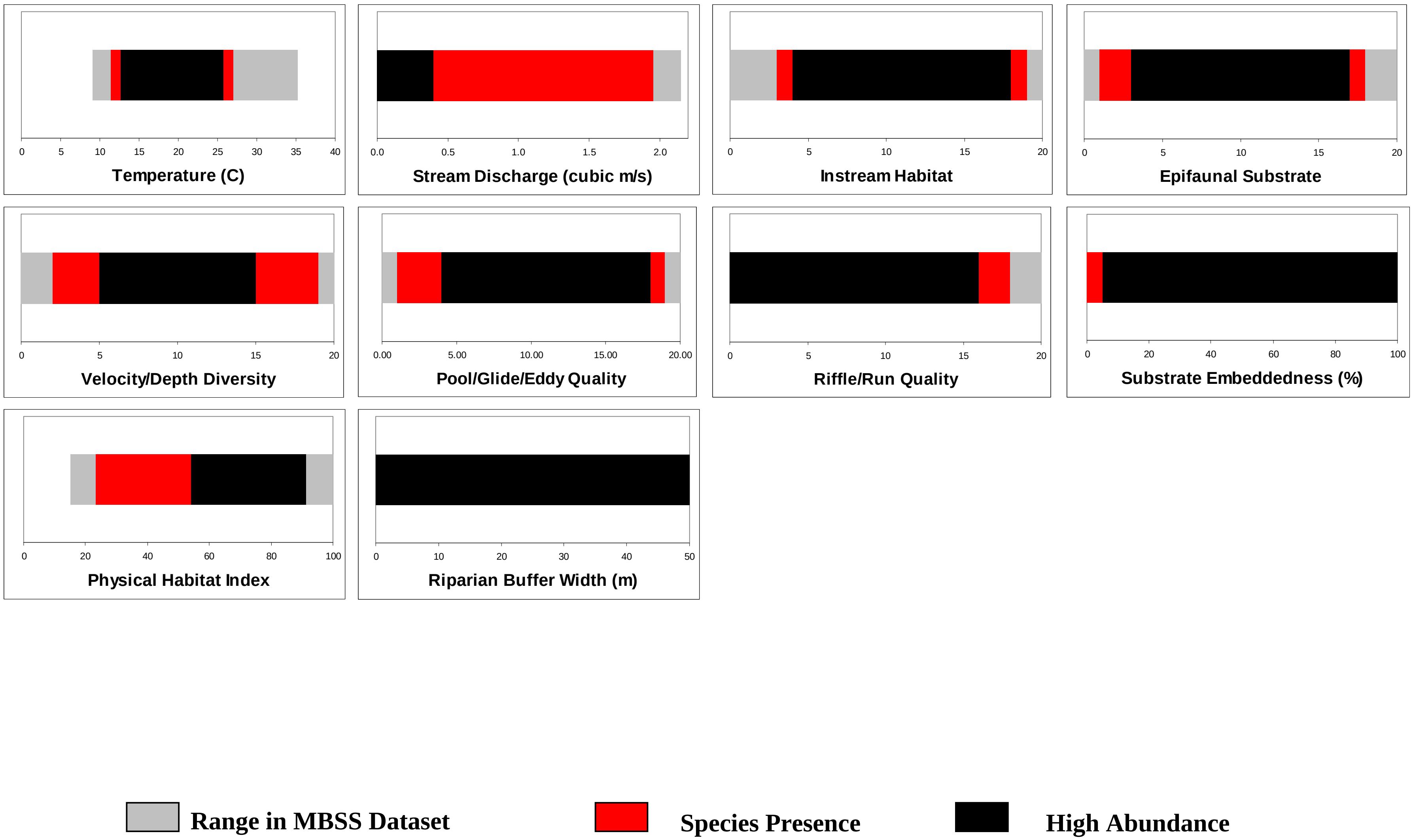
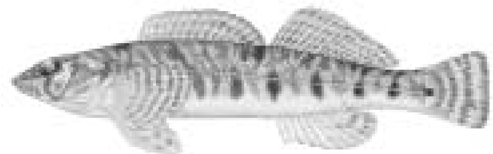


Fig. A-27: continued.



Logperch Illustration by: D.A. Neely
Percina caprodes

Life History:

Adult Size: 95-110 mm TL (Jenkins and Burkhead 1994).

Longevity: 4 years (Jenkins and Burkhead 1994).

Diet: Small crustaceans, aquatic insects, and fish eggs on occasion (Mullan et al. 1968; Thomas 1970; Jenkins and Burkhead 1994).

Fecundity: Females produce 1000-3,100 eggs (Winn 1958b; Jenkins and Burkhead 1994).

Spawning: Spawning occurs from mid- March to mid-July at temperatures above 10 °C. (Hubbs and Strawn 1963; Page 1983; Jenkins and Burkhead 1994). Spawning takes place over sand or gravel. Spawning groups consist of multiple males and a single female; eggs are buried in substrate during the spawning act (Reighard, J. 1913; Winn 1958a, 1958b; Jenkins and Burkhead 1994).

Habitat: Logperch inhabits moderate gradient, warmwater streams and rivers. This species has been collected in tidal freshwaters in Maryland (Mansueti 1964). Logperch are commonly found in riffle, run, and pool habitats (Jenkins and Burkhead 1994).

Migration: Adults of lacustrine populations are known to make localized migrations to nearshore spawning habitats (Scott and Crossman 1973). Migration in lotic populations is relatively unknown, however localized movements to preferred spawning habitats are likely.

Distribution and Abundance:

Distribution: Historically, logperch has been collected in the lower Susquehanna River, Winters Run (a tributary to the Bush River), and from the Potomac River near Washington D.C. (Lee et al. 1981). Extant populations of logperch are known from portions of the Susquehanna River and Elk River drainage basins (Fig.A-28).

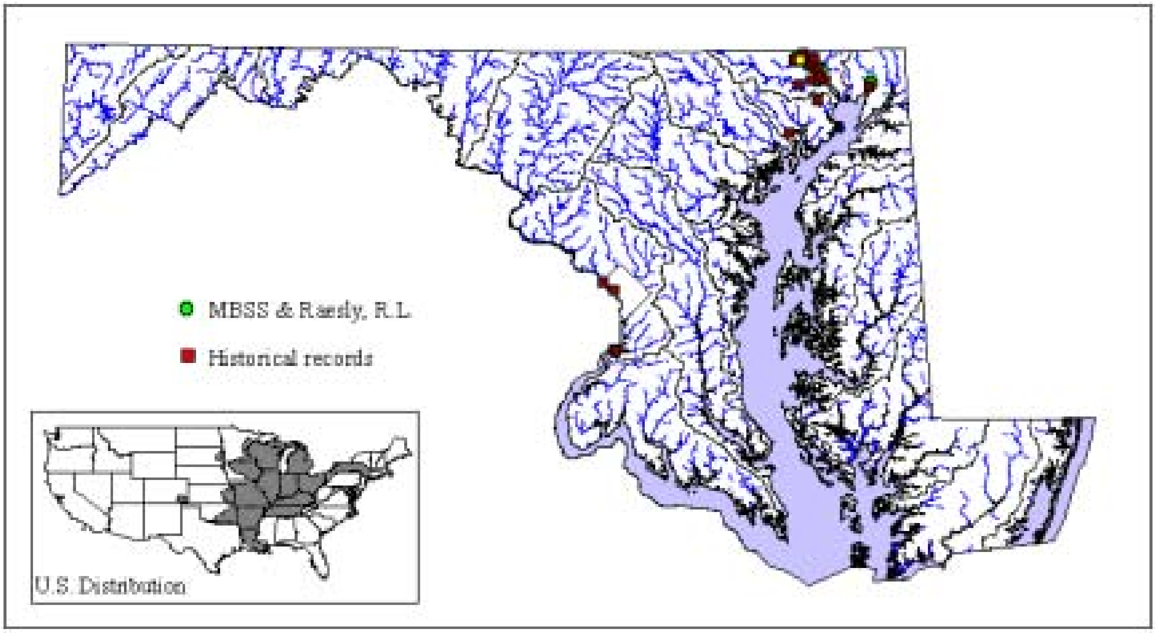


Fig A-28. Records for logperch in Maryland.

Status and Abundance: Logperch is considered globally secure. The status of this species in Maryland, as determined by the Maryland Department of Natural Resources, is Threatened (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 1,342 ± 1,342 logperch in Maryland. Information from a morphological study (George 2005) and mitochondrial DNA analyses (Near and Benard 2004) indicates that the logperch of the lower Susquehanna River watershed in Maryland and Pennsylvania is likely a distinct species. If proven to be distinct, it will be eligible for immediate consideration as a federally endangered species.

Key Habitats: Logperch is associated with Piedmont Rivers (MDNR 2005). The stronghold watersheds for logperch include Conowingo Dam, Northeast River, Deer Creek, Broad Creek, and Octoraro Creek. These watersheds are essential for the conservation of logperch in Maryland.

Species Associations: A total of 46 different fish species were present at sites where logperch was collected. The five species that most often co-occurred with logperch included: tessellated darter, river chub, common carp (non-native), white sucker, and smallmouth bass (non-native).

Stressors: Logperch populations in Maryland are located in larger streams of the upper Chesapeake Bay. These predominately agricultural tributaries are experiencing increased pressures associated with suburban sprawl. The affinity of logperch for silt-free substrate for spawning makes this species vulnerable to excessive stream sedimentation commonly associated with landscape alteration. Urbanization increased in each of the five stronghold watersheds during the period of 1973 to 2000 (Table A-1). Adverse changes to stream conditions common with urban development may affect downstream logperch populations. Additionally, stream blockages in these watersheds may limit access of these populations to upstream habitats. A list of other stressors in watersheds with logperch populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by logperch, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-29. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of logperch in Maryland requires the protection of silt-free spawning habitats. Management practices designed to limit channel alteration, stream bank erosion, and stream sedimentation will minimize loss of logperch spawning habitats. Restoration of riparian buffers, removal of stream blockages, and the full mitigation of urbanization will serve to protect logperch populations in their stronghold watersheds. Surface water withdrawals in Deer Creek watershed should be limited so as not to reduce suitable habitat for this species. Management that aims to preserve or enhance the connectivity of critical logperch habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified logperch populations in five 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, populations of logperch are known from the mainstem Susquehanna River and portions of the upper Chesapeake Bay, areas not sampled by MBSS. Additional random sampling and targeted surveys within large tidal and non-tidal rivers will improve our understanding of logperch abundance and the extent of logperch distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable logperch habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of this species. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of logperch populations and critical habitats.

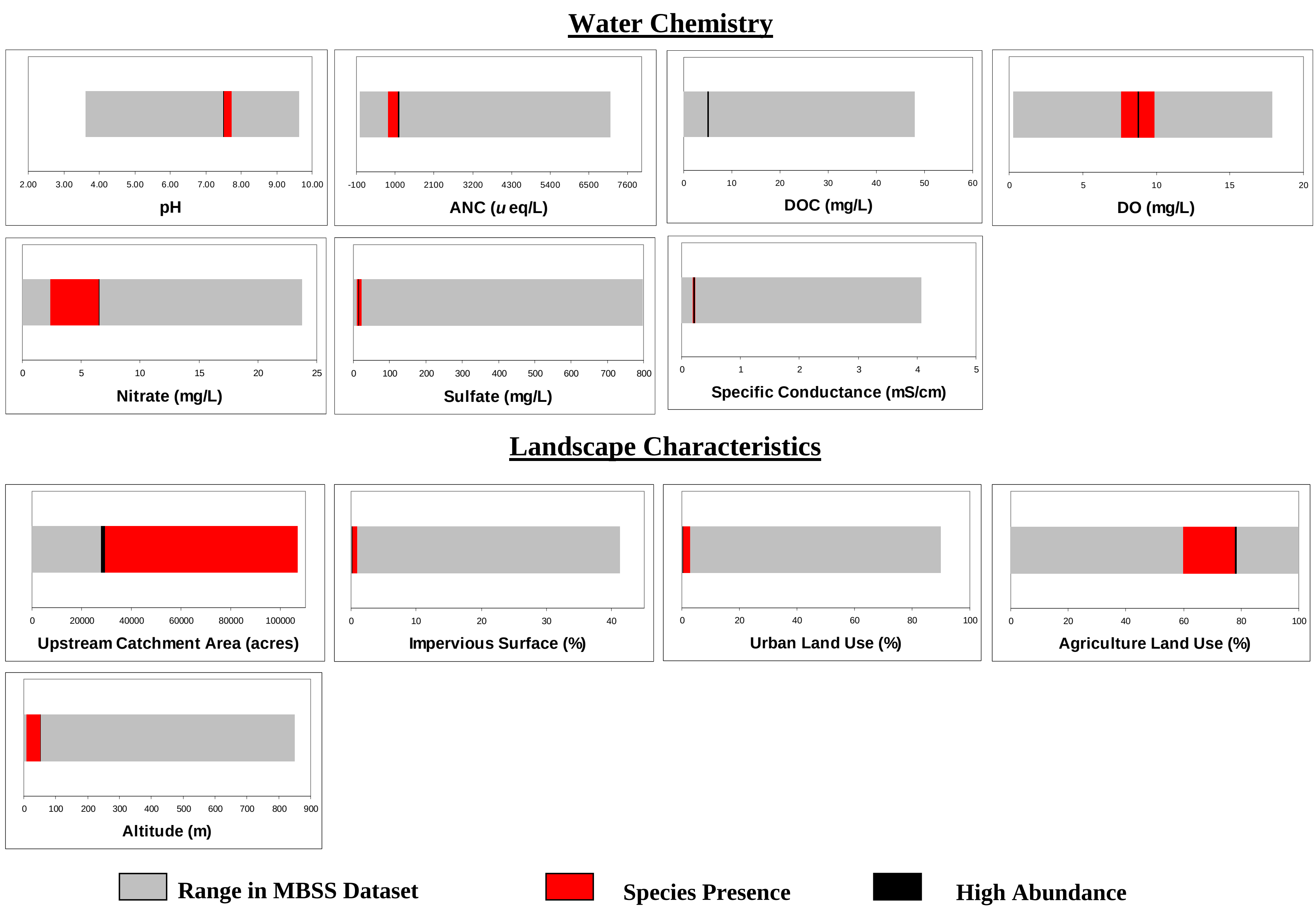


Fig. A-29: Logperch range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

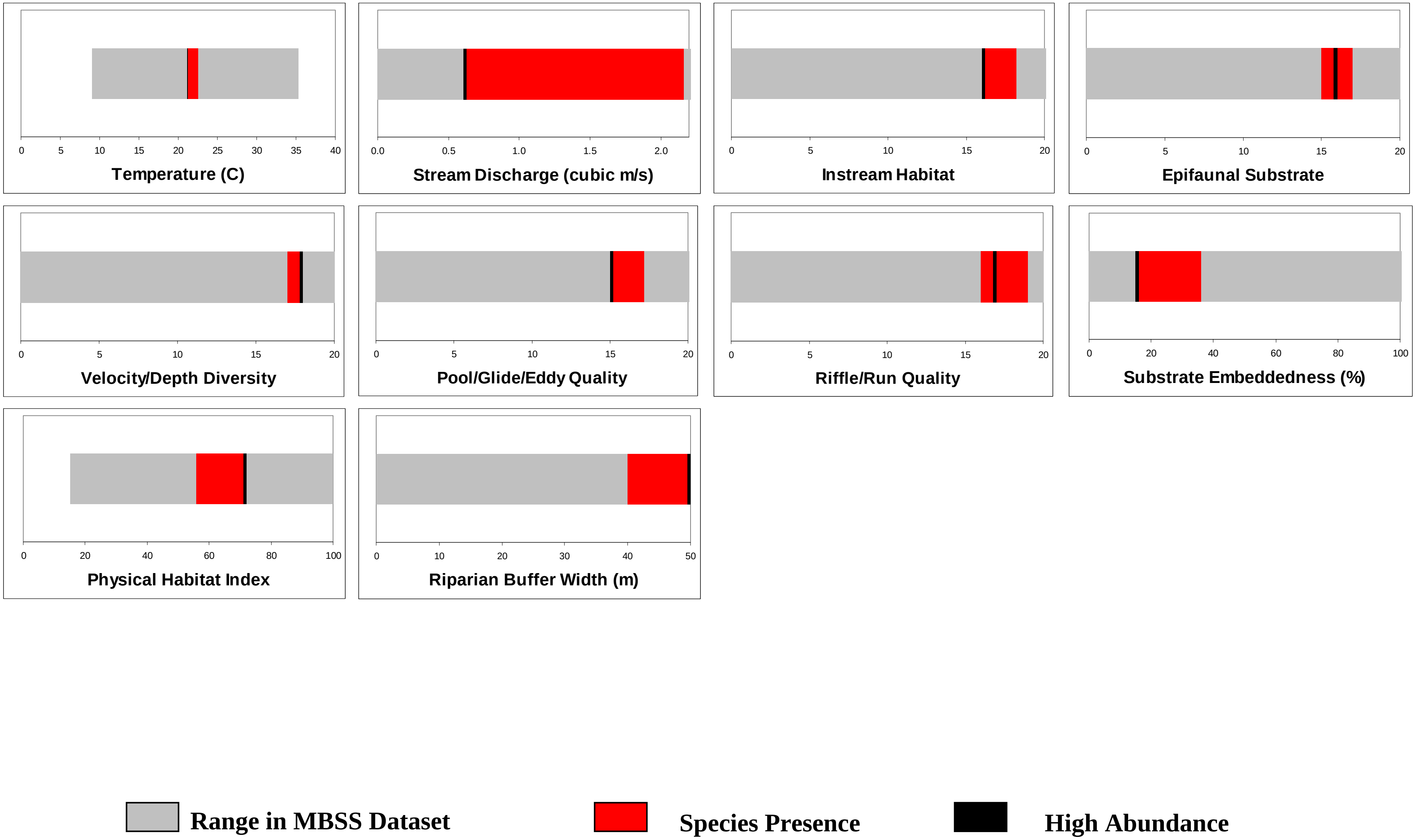
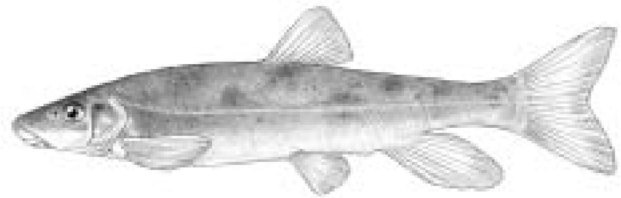


Fig. A-29: continued.



Longnose Sucker Illustration by: D.A. Neely
Catostomus catostomus

Life History:

Adult Size: Varies with locality, largest recorded specimen was 643 mm TL (Lee et al. 1980).

Longevity: >10 years (Harris 1962; Lee et al. 1980).

Diet: Benthic invertebrates (Lee et al. 1980).

Fecundity: Unknown

Spawning: Mid-April to mid-May in temperatures as low as 5°C. Adults move into streams for spawning (Lee et al. 1980)

Habitat: Longnose sucker inhabits clear, cold waters of lakes, streams, and rivers (Lee et al. 1980).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Historically, longnose suckers were collected from Whitehorn Lake (an impoundment of Herrington Creek) in Garrett County, Maryland (Mansuetti 1957). This population is now extirpated (Hendricks 1979). More recently, this species was collected in the Youghiogheny River basin in the Casselman River, Buffalo Run, and Mill Run watersheds of western Maryland (Hendricks et al. 1979; Hendricks 1980; Lee et al. 1981). Extensive sampling by the MBSS (1994-2004) and Raesly (1995) failed to identify any extant populations of this species (Fig.A-30).

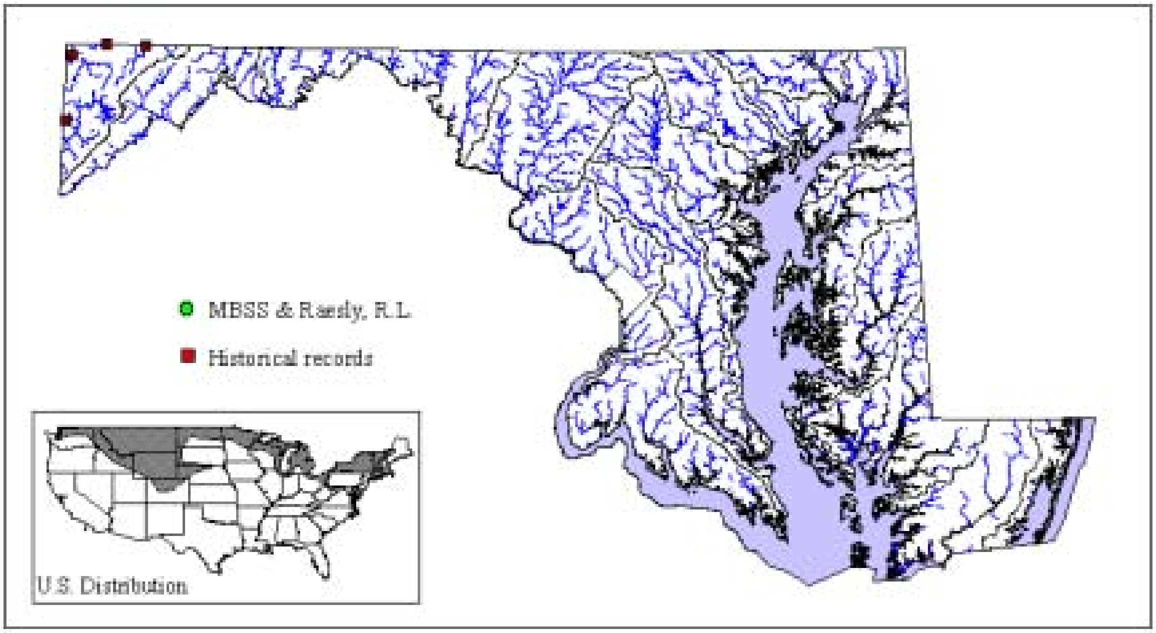


Fig.A-30. Records for longnose sucker in Maryland.

Status and Abundance: Longnose sucker is considered globally secure, but rare in parts of its range. Longnose sucker is a GCN species in Pennsylvania. The status of this species, as determined by the Maryland Department of Natural Resources, is Endangered Extirpated (COMAR 08.03.08).

Key Habitats: This species is associated with coldwater streams and impoundments (MDNR 2005).

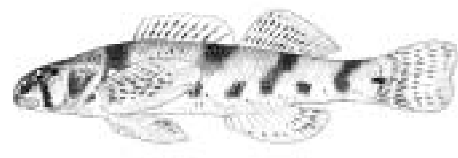
Stressors: Given its propensity for cold, silt-free water, land use practices that result in the increase in stream temperatures and siltation of stream substrates are detrimental to longnose sucker populations. Practices associated with agriculture, such as the removal of riparian buffers, may have reduced or eliminated longnose sucker populations from historic locations.

Conservation Actions:

Re-establishment of longnose sucker populations using stock from nearby Pennsylvania populations should be considered, following restoration and protection of coldwater habitats preferred by this species. A captive breeding program would also supplement re-establishment of longnose sucker in historical locations of Maryland.

Monitoring, Planning and Coordination Needs:

Additional sampling surveys of potential habitat in the Youghiogheny River basin are necessary to determine whether or not viable populations of longnose sucker still reside in Maryland. Targeted sampling should be focused in areas with coldwater, silt-free habitats preferred by longnose sucker. Targeted sampling in these areas may identify currently unknown populations of this species.



Maryland Darter Illustration by: D.A. Neely
Etheostoma sellare

Life History:

Adult Size: 47.3-70 mm SL (Knapp 1976).

Longevity: 2-3 years (Knapp 1976).

Diet: Aquatic insects and snails (Knapp 1976; Page 1983).

Fecundity: Unknown, although one preserved specimen contained 407 eggs (Knapp 1976).

Spawning: Spawning of the Maryland darter most likely occurs in April; post-spawning specimens have been collected in mid-May (Knapp 1976).

Habitat: Habitat preferences of the Maryland darter are relatively unknown, although the majority of specimens collected were associated with a large riffle near the mouth of Deer Creek in Harford County, Maryland.

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Maryland darter is reported from only three locations in Harford County, Maryland (Fig. A-31). All three locations were in tributaries draining to the upper Chesapeake Bay (Radcliffe and Welsh 1913; Knapp 1976). The majority of specimens ever collected were taken from a population located near the mouth of Deer Creek. A total of seven adult Maryland darters were observed in Deer Creek from 1986-1988. The Maryland darter has not been seen since August 21,1988 (Raesly 1991).

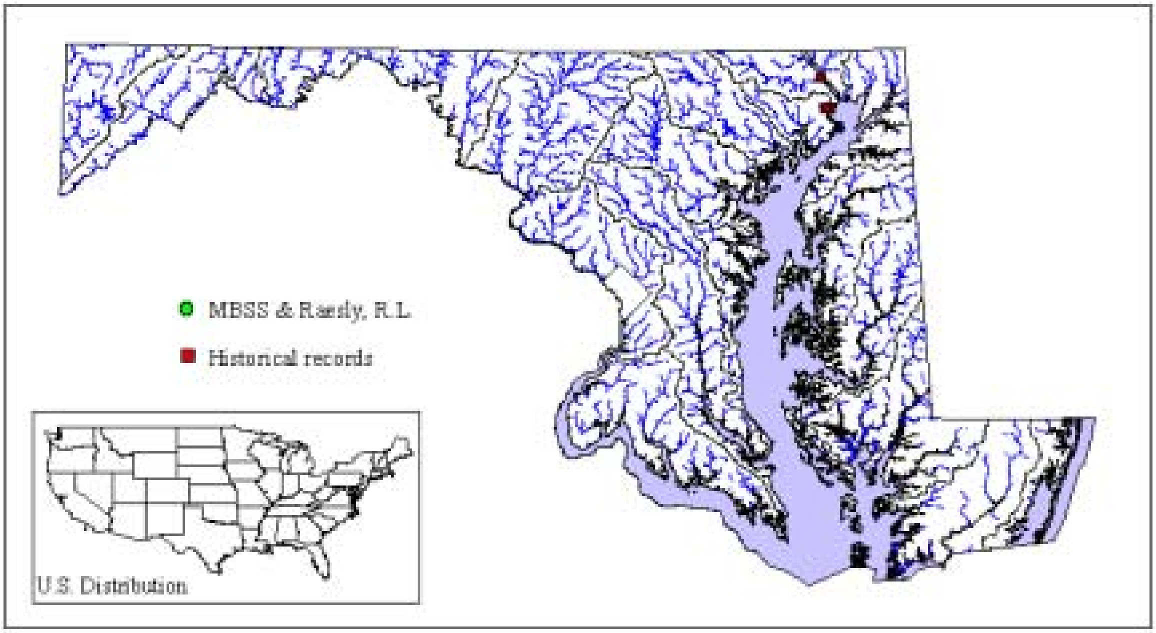


Fig. A-31. Records for Maryland darter in Maryland.

Status and Abundance: Maryland darter is federally endangered species. In Maryland, the status of this species, as determined by the Maryland Department of Natural Resources, is Endangered (COMAR 08.03.08).

Key Habitats: Maryland darter is associated with Coastal Plain and Piedmont streams (MDNR 2005). All locations where this species has been observed are located near the mouths of tributaries to the upper Chesapeake Bay.

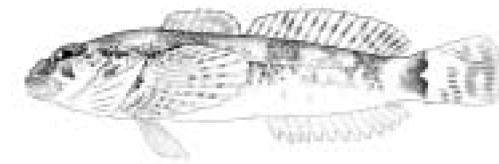
Stressors: Little is known regarding the habitat preferences and requirements of the Maryland darter. The largest population of Maryland darter is known from Deer Creek, a watershed that is predominately agricultural (Table A-1). Practices associated with agriculture, such as the removal of riparian buffers and the application of fertilizers and pesticides, as well as municipal water withdrawals from the mainstem of Deer Creek, may have limited the long-term sustainability of the Maryland darter populations at this location.

<u>Conservation Actions:</u>

Management aimed at improving riparian zone conditions and reducing nutrient and sediment run-off from agricultural fields would benefit water and habitat quality of the lower Deer Creek mainstem. Full mitigation of urbanization and management designed to limit the amount of impervious surface will benefit Maryland darter populations in Deer Creek watershed. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

Additional sampling surveys of potential habitat in the tributaries to the upper Chesapeake Bay are necessary to determine whether or not viable populations of Maryland darter still reside in Maryland. Targeted sampling should be focused in the mainstem of Susquehanna River below the mouth of Deer Creek. Targeted sampling in these areas may identify currently unknown populations of Maryland darter.



Mottled sculpin
Cottus bairdi

Illustration by: D.A. Neely

Life History:

Adult Size: 43-125 mm SL (Lee et al. 1980; Jenkins and Burkhead 1994).

Longevity: Maximum of 6 years (Reagan and West 1985; Jenkins and Burkhead 1994).

Diet: Primarily aquatic insects; also small crustaceans, occasional fish, and fish eggs (Koster 1937; Bailey 1952; Dineen 1951; Rohde and Arndt 1981; Etnier and Starnes 1993; Jenkins and Burkhead 1994).

Fecundity: Females produce 35-406 eggs, although fecundity varies over the extent of the species range (Koster 1936; Rohde and Arndt 1981; Etnier and Starnes 1993; Jenkins and Burkhead 1994).

Spawning: From Virginia data, spawning occurs from mid-March to April (Jenkins and Burkhead 1994). Eggs are deposited in nest cavities under rock substrates or placed on or under a variety of substrates including vegetation, logs, gravel, etc (Koster 1936; Rohde and Arndt 1981; Jenkins and Burkhead 1994). Males select and defend spawning territories; multiple females spawn with single males (Jenkins and Burkhead 1994).

Habitat: Mottled sculpin inhabits cool, moderate and high gradient streams and rivers. This species is commonly found in riffle and run habitats over a variety of substrate types and sizes (Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: In Maryland, extant populations of mottled sculpin are known from the Youghiogheny River basin in Western Maryland (Fig.A-32). The only known Atlantic slope population is located in Wills Creek, a tributary to the North Branch Potomac River basin. This population is the result of a stream capture event between the upper tributaries of Wills Creek and

Blue Lick Creek watershed of the Youghiogheny River. Mottled sculpin populations in Wills Creek are confined to the Pennsylvania portion of this watershed (Kinziger and Raesly 2001).

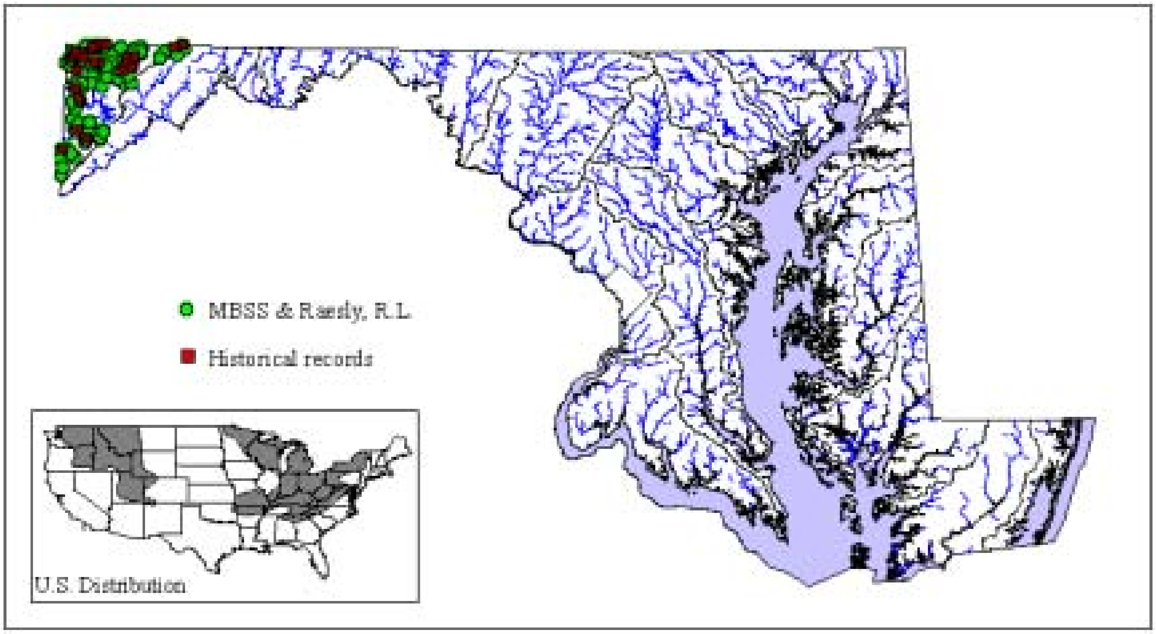


Fig. A-32. Records for mottled sculpin in Maryland.

Status and Abundance: Although it is not currently listed as a rare, threatened, or endangered species in Maryland, the mottled sculpin has a restricted distribution in the state. Based on quantitative MBSS electrofishing data, there are currently an estimated 687,961 ± 186,349 mottled sculpin in Maryland.

Key Habitats: Mottled sculpin is commonly associated with Highland and Coldwater stream types in Western Maryland. The stronghold watersheds for mottled sculpin include the Casselman River, Little Youghiogheny River, and the Youghiogheny River. These watersheds are essential for the conservation of mottled sculpin in Maryland.

Species Associations: A total of 60 different fish species were present at sites where mottled sculpin was collected. The five species that most often co-occurred with mottled sculpin included: blacknose dace, creek chub, white sucker, longnose dace, and brook trout.

Stressors: Given its restricted distribution and propensity for clear, cool to cold stream waters, this species would be susceptible to stream degradation caused by human disturbance. Mottled sculpin populations are restricted to the Youghiogheny River basin in Western Maryland. This restricted population makes this species vulnerable to land use change within this basin. Each of the three stronghold watersheds have undergone slight increases in urban land use during the period of 1973 to 2000 (Table A-1). Increased stream temperatures associated with urban land use and impervious surfaces may reduce coldwater mottled sculpin habitats in these watersheds. Land use change, if continued, could eventually degrade critical habitats and reduce populations in these watersheds. Sedimentation and removal of forested stream buffers generally associated with logging practices and changes in water chemistry associated with acid mine drainage are important stressors that may be affecting this species. Future increases in stream temperatures caused by groundwater withdrawals, removal of streamside trees, and global warming may reduce suitable mottled sculpin habitat. A list of other stressors in watersheds with mottled sculpin populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by mottled sculpin, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-33. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of mottled sculpin in Maryland requires full mitigation of logging practices and acid mine drainage within the Youghiogheny watershed. Full mitigation of urbanization and management designed to limit impervious surface will benefit mottled sculpin populations. Additionally, management that aims to preserve or enhance the connectivity of mottled sculpin habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified mottled sculpin populations in three 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of mottled sculpin abundance and the extent of mottled sculpin distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable mottled sculpin habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of mottled sculpin. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of mottled sculpin populations and critical habitats.

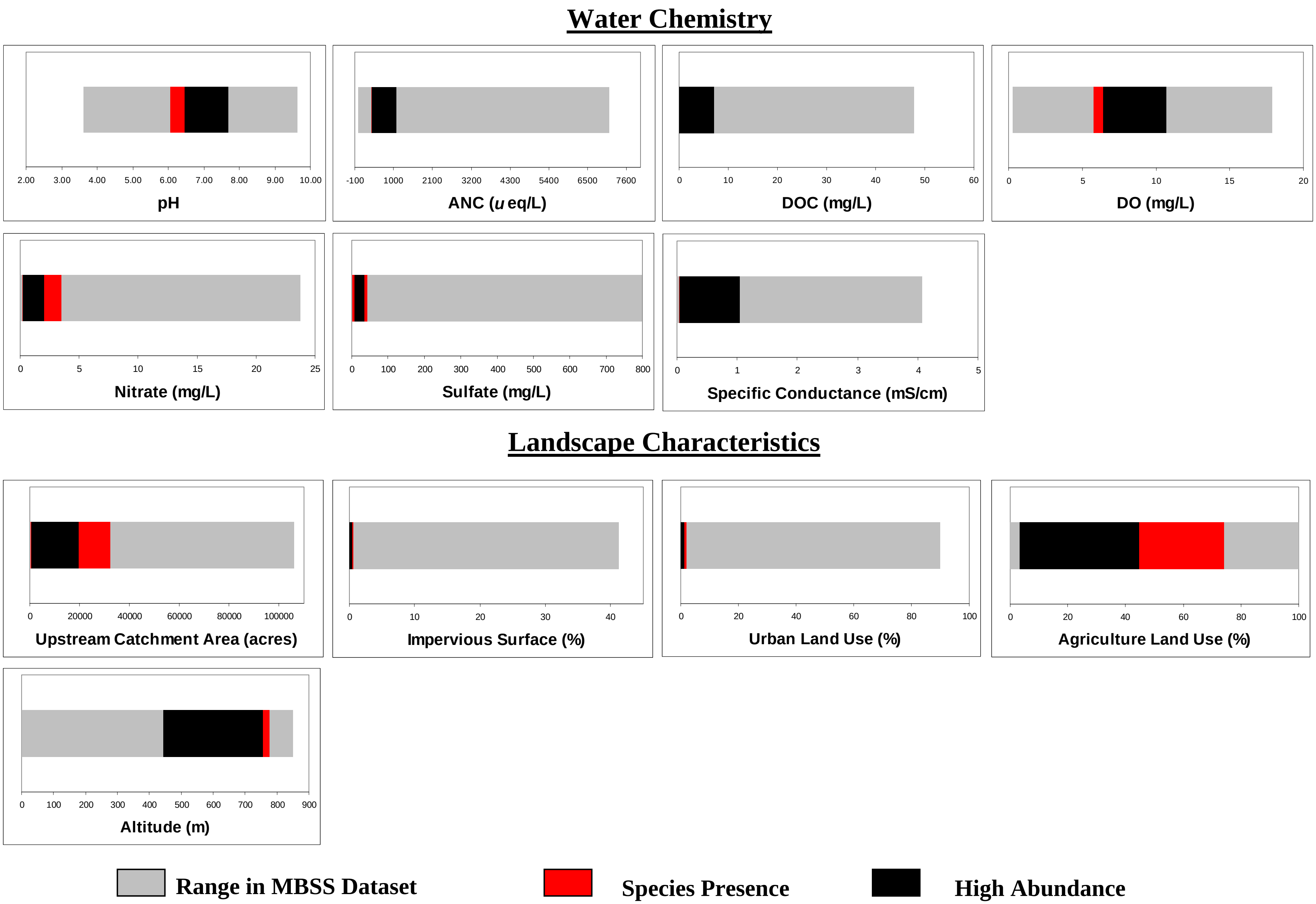


Fig. A-33: Mottled sculpin range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

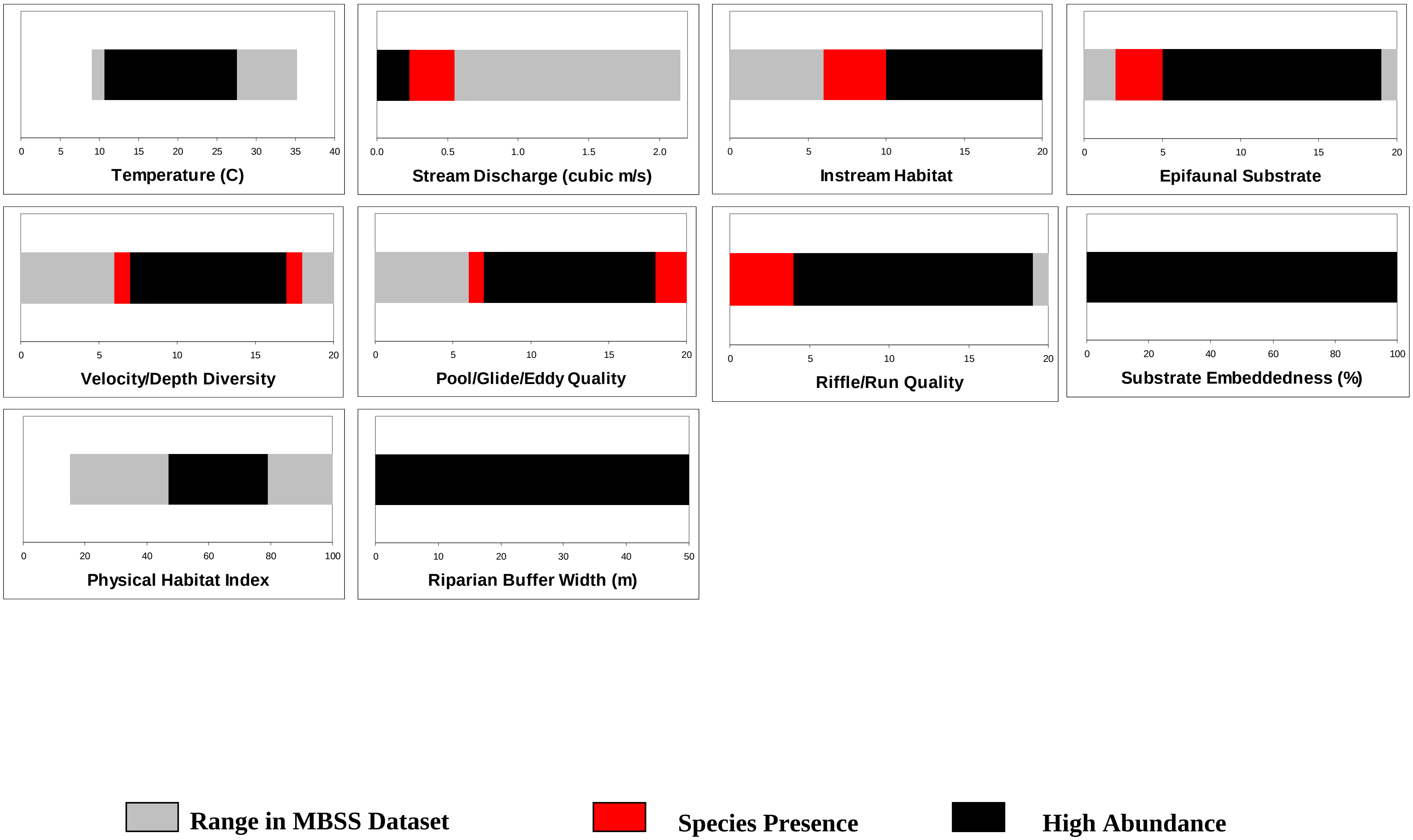
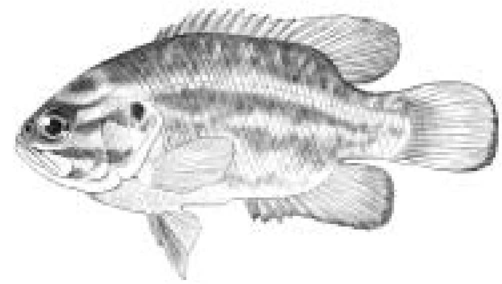


Fig. A-33: continued.



Mud Sunfish Illustration by: D.A. Neely

Acantharchus pomotis

Life History:

Adult Size: 111-206 mm TL (Breder and Redmond 1929; Mansueti and Elser 1953; Elser 1961; Lee et al. 1980; Jenkins and Burkhead 1994)

Longevity: 8 years (Mansueti and Elser 1953).

Diet: Small crustaceans, aquatic insects, and occasionally small fishes (Jenkins and Burkhead 1994).

Fecundity: Unknown.

Spawning: Spawning period in the Mid-Atlantic region is generally unknown (Jenkins and Burkhead 1994). Nesting occurs in early June in New Jersey over silt substrate within vegetation (Breder 1936).

Habitat: Mud sunfish occupies ponds, swamps, and slow-moving pool habitats of streams with silt substate (Lee et al. 1980; Jenkins and Burkhead 1994). This species is known to tolerate low pH waters (Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: The geographic distribution of mud sunfish in Maryland is sporadic and confined to the Coastal Plain of Delmarva Peninsula. Extant populations of mud sunfish are known from portions of the Chester River, Choptank River, Nanticoke/Wicomico River, and Pocomoke River drainage basins (Fig.A-34).

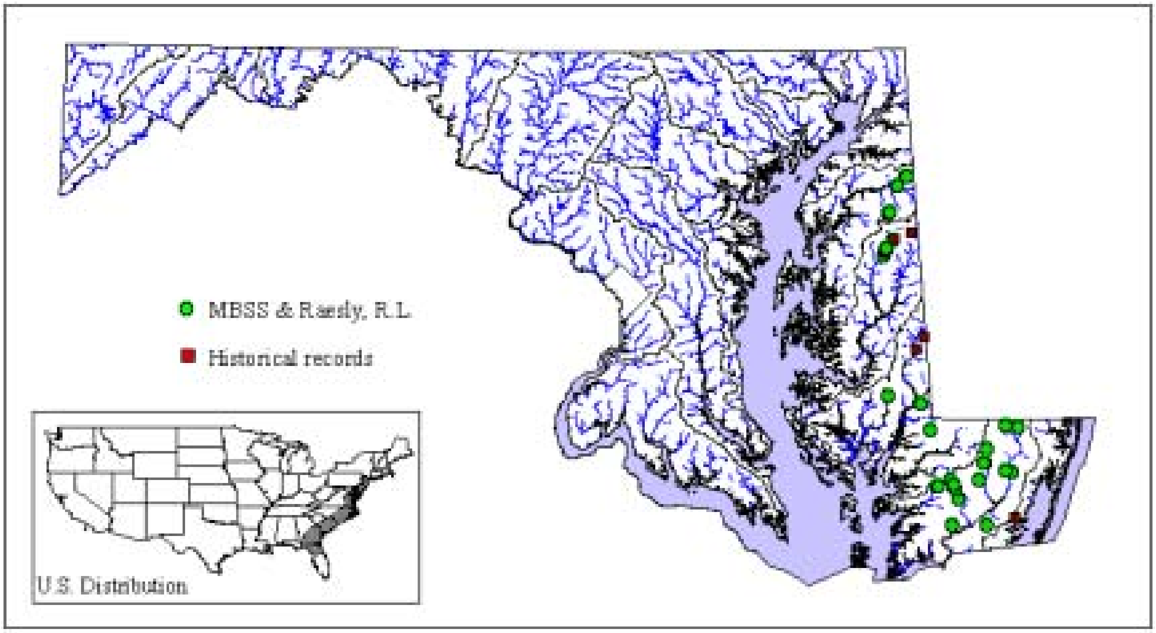


Fig. A-34. Records for mud sunfish in Maryland.

Status and Abundance: Mud sunfish is considered globally secure, but rare in parts of its range. This species is a GCN species in Pennsylvania, Virginia, and Delaware. The status of this species, as determined by the Maryland Department of Natural Resources, is In Need of Conservation (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 9,128 ± 3,377 mud sunfish in Maryland.

Key Habitats: Mud sunfish is associated with Blackwater and Coastal Plain stream types (MDNR 2005). The stronghold watersheds for mud sunfish include Wicomico Creek, Dividing Creek, Manokin River, Upper Chester River, and the Lower Pocomoke River. These watersheds are essential for the conservation of mud sunfish in Maryland.

Species Associations: A total of 29 different fish species were present at sites where mud sunfish was collected. The five species that most often co-occurred with mud sunfish included: eastern mudminnow, pirate perch, redfin pickerel, American eel, and creek chubsucker.

Stressors: Mud sunfish populations in Maryland are located in largely agricultural watersheds (Table A-1). Practices associated with agriculture, such as stream channelization, application of fertilizers and pesticides, removal of riparian zones, and the application of lime may reduce or degrade the swampy, slow-water habitats preferred by this species. Urban land use has increased in three of the stronghold watersheds for this species, Wicomico Creek, Manokin River, and Upper Chester River. Land use change, if continued, could eventually degrade critical habitats and reduce populations in these watersheds. A list of other stressors in watersheds with mud sunfish populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by mud sunfish, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-35. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of mud sunfish in Maryland requires the protection of critical habitats. Restoration of riparian buffers and the reduction (or full elimination) of stream channelization will serve to protect these habitats. Farming practices that aim to reduce nutrient and pesticide run-off will protect mud sunfish habitats. Additionally, management that aims to preserve or enhance the connectivity of critical habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified mud sunfish populations in ten 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of mud sunfish abundance and the extent of mud sunfish distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable mud sunfish habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of mud sunfish. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of mud sunfish populations and critical habitats.

Water Chemistry

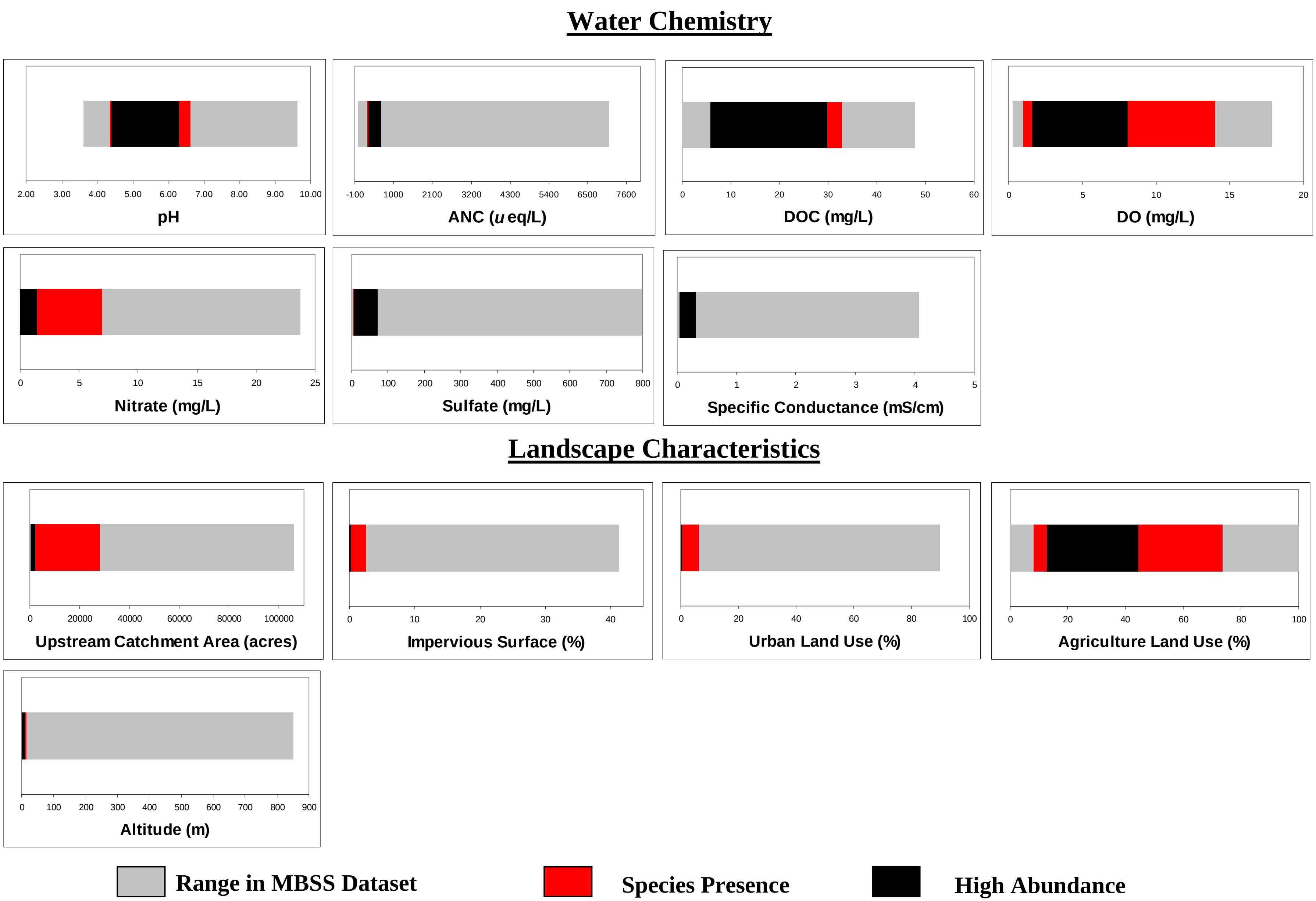


Fig. A-35: Mud sunfish range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

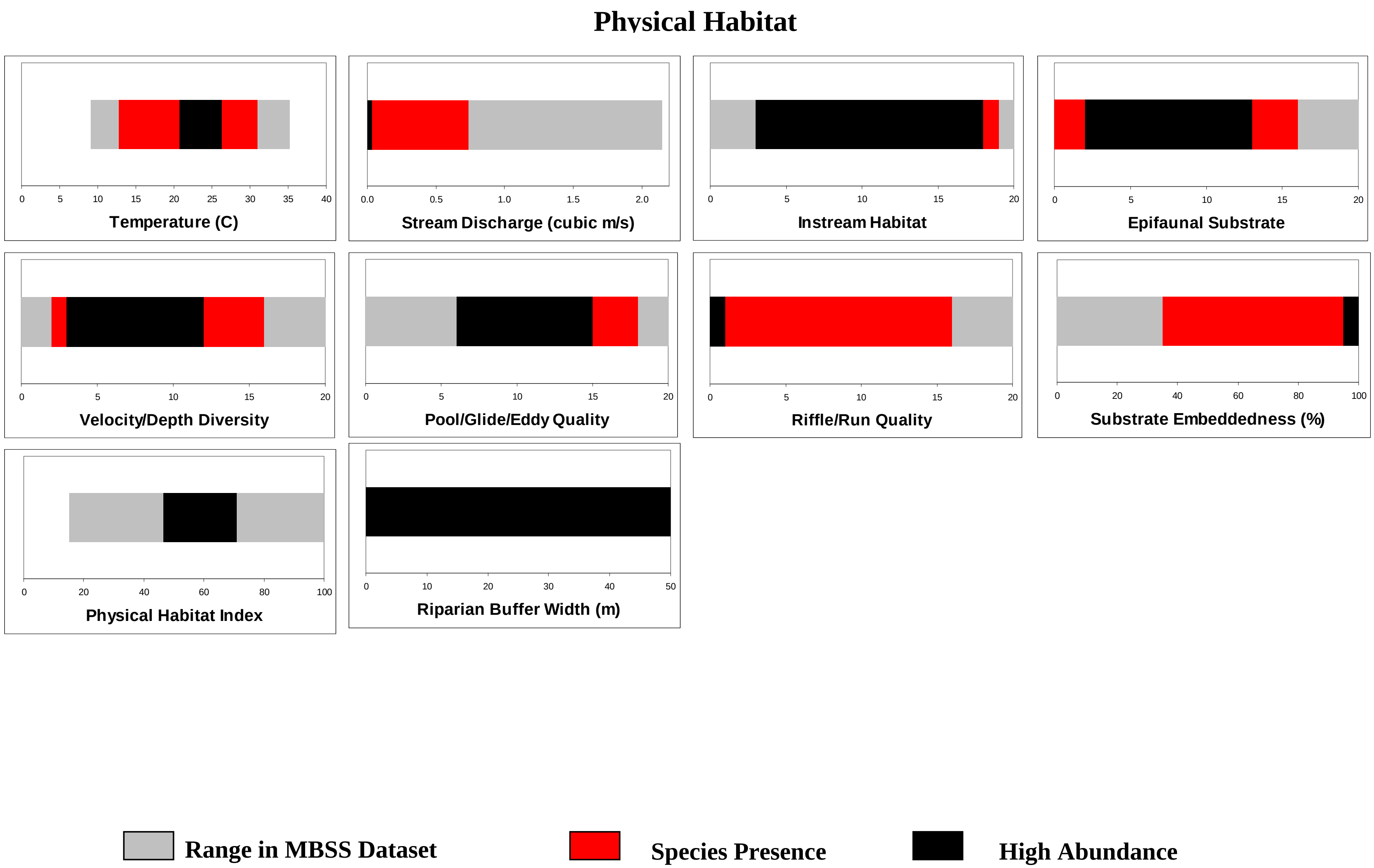
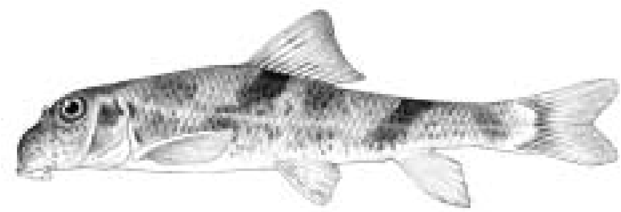


Fig. A-35: continued.



Northern Hogsucker Illustration by: D.A. Neely
Hypentelium nigricans

Life History:

Adult Size: 135-460 mm TL (Lee et al. 1980).

Longevity: 10 years (Raney and Lachner 1946; Jenkins and Burkhead 1994).

Diet: Small crustaceans, aquatic insects, small mollusks, and algae on occasion (Forbes 1903; Jenkins and Burkhead 1994).

Fecundity: Unknown

Spawning: Spawning occurs from late- March to late-May in Virginia. (Jenkins and Burkhead 1994). Spawning takes place over gravel in riffles or pools. Spawning groups consist of multiple males (3-11) and a single female (Raney and Lachner 1946; Jenkins and Burkhead 1994).

Habitat: Northern hogsucker inhabits low to moderate gradient, clean streams and rivers. Northern hogsucker is commonly found in riffle, run, and pool habitats and typically associated with hard substrates (Jenkins and Burkhead 1994).

Migration: Adults migrate locally to preferred seasonal habitats (Matheney and Rabeni 1995).

Distribution and Abundance:

Distribution: With the exception of the Coastal Plain, Northern hogsucker is widespread in Maryland. Extant populations of Northern hogsuckers are known from portions of Elk River, Susquehanna River, Bush River, Gunpowder River, Patapsco River, Patuxent River, Potomac Washington Metro, Middle Potomac River, Upper Potomac River, North Branch Potomac River, and the Youghiogheny River drainage basins (Fig.A-36).

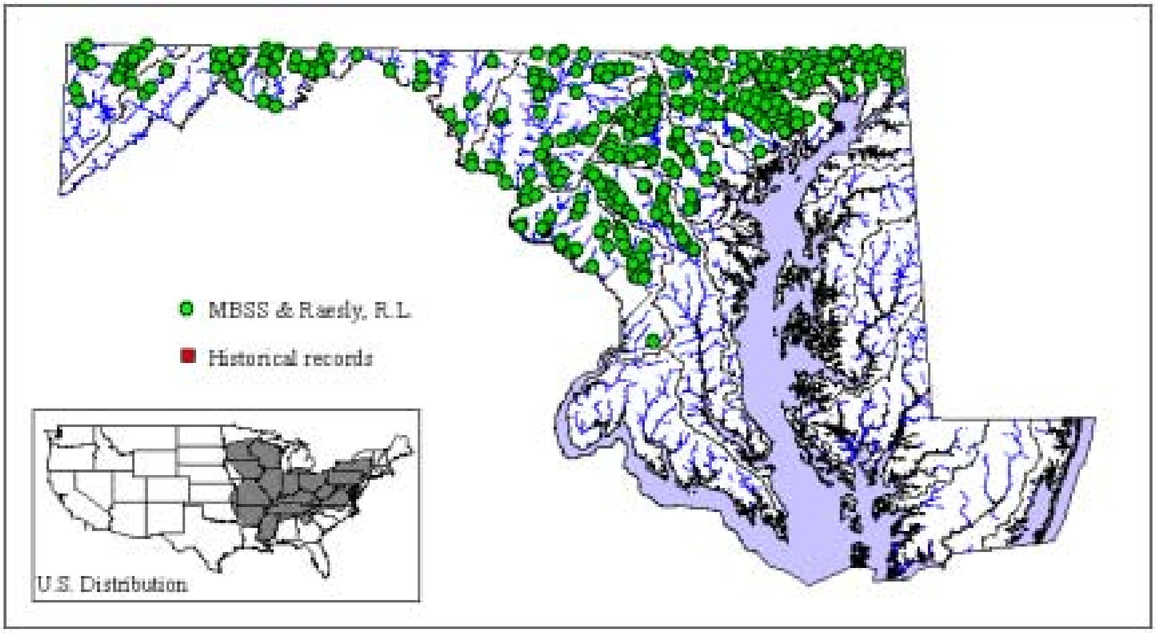


Fig. A-36. Records for Northern hogsucker in Maryland.

Status and Abundance: Although it is not currently listed as a rare, threatened, or endangered species in Maryland, Northern hogsucker is considered intolerant to anthropogenic stress (Roth et al. 1997). Based on quantitative MBSS electrofishing data, there are currently an estimated 265,115 ± 62,861 Northern hogsucker in Maryland. However, due to the presence of this species in the mainstem of large rivers not sampled by MBSS, this estimate is likely low.

Key Habitats: Northern hogsucker is associated with Highland, Piedmont, and Coldwater stream types (MDNR 2005). The stronghold watersheds for Northern hogsucker include Bynum Run, Atkisson Reservoir, Big Elk Creek, Conowingo Dam, Lower Winters Run, and Little Conococheague Creek. These watersheds are essential for the conservation of Northern hogsucker in Maryland.

Species Associations: A total of 76 different fish species were present at sites where Northern hogsucker was collected. The five species that most often co-occurred with Northern hogsucker included: white sucker, longnose dace, blacknose dace, creek chub, and tessellated darter.

Stressors: Given the widespread distribution of Northern hogsucker in Maryland, stressors and threats to this species vary by watershed. Adverse changes in stream conditions commonly associated with urbanization have reduced or eliminated populations of Northern hogsucker in portions of Maryland

(Stranko et al. 2005). Extensive urbanization has occurred in Lower Winters Run, Atkisson Reservoir, Bynum Run, Conowingo Dam, and Big Elk Creek watersheds (Table A-1). The increase in urban land use coincided with a proportional loss of forested and agricultural lands. Based on the existing state of knowledge about adverse changes in stream temperature, stream water chemistry, stream velocity, and physical habitat quality associated with increasing urbanization, populations of Northern hogsucker in these watersheds are likely declining. This species is known to prefer clean gravel substrate for spawning and, therefore, is sensitive to siltation and channel modification (Trautman 1981; Jenkins and Burkhead 1994). A list of other stressors in watersheds with Northern hogsucker populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by American brook lamprey, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-37. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of Northern hogsucker in Maryland requires the protection of the silt-free spawning habitats. Soil conservation and best management practices designed to limit channel alteration, stream bank erosion, and stream sedimentation will protect populations of northern hogsucker in agricultural watersheds. Full mitigation of urbanization and management designed to limit the amount of impervious surface will benefit populations of Northern hogsucker in the Lower Winters Run, Atkisson Reservoir, Bynum Run, Conowingo Dam, and Big Elk Creek watersheds. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified Northern hogsucker populations in 54 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling will improve our understanding of Northern hogsucker distribution and abundance, and track changes over time. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of Northern hogsucker populations and critical habitats.

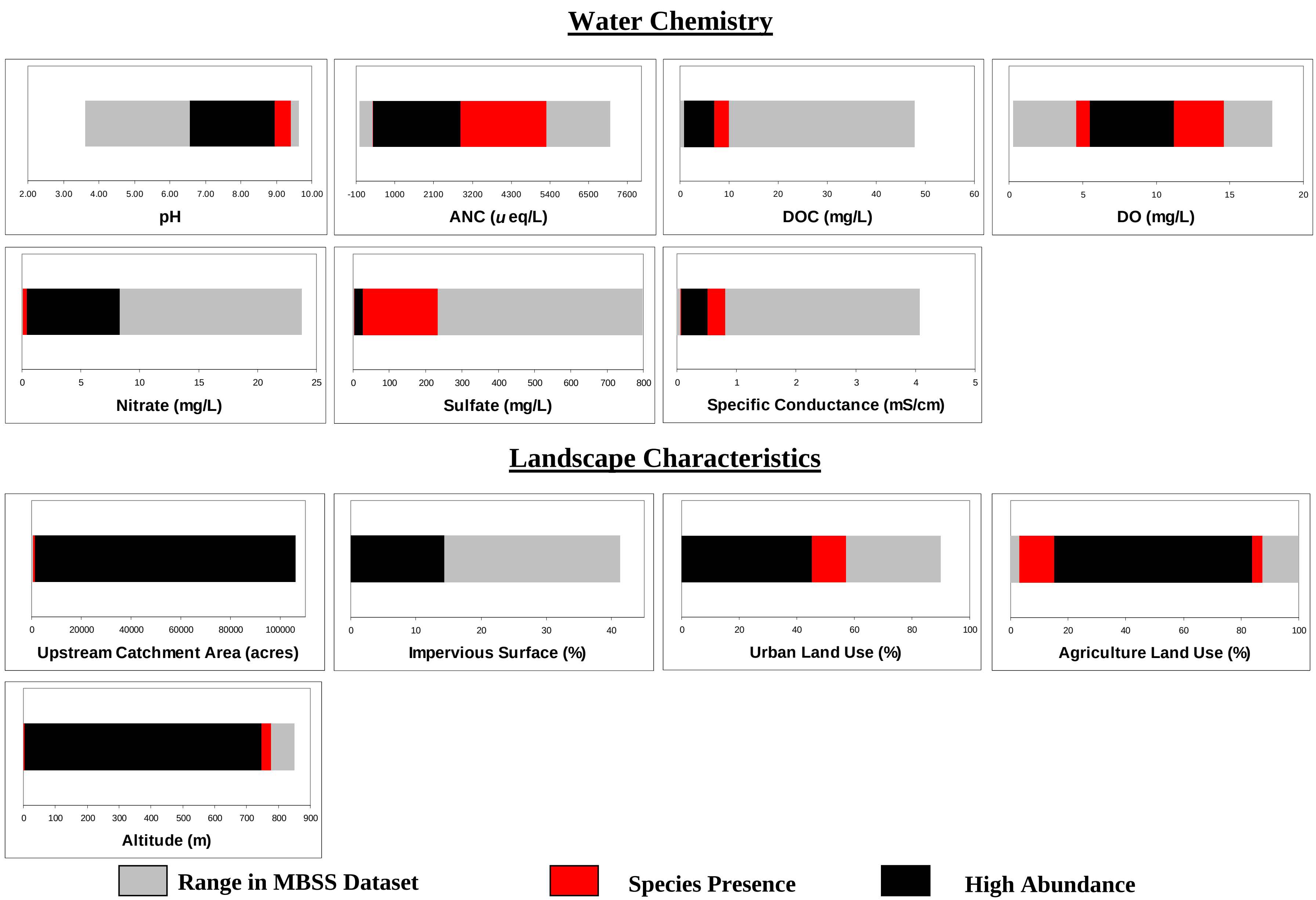


Fig. A-37: Northern hogsucker range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

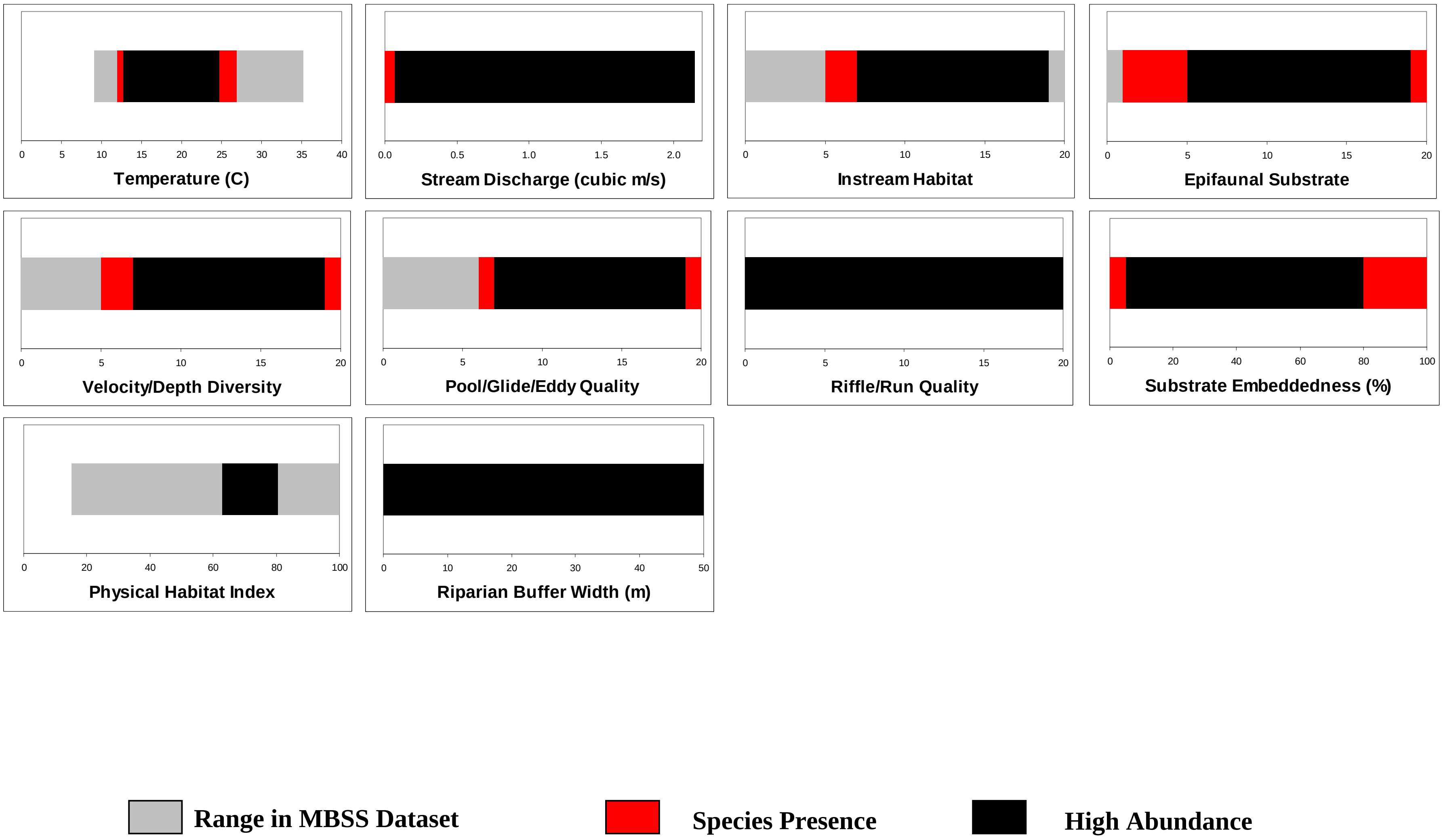


Fig. A-37: continued.

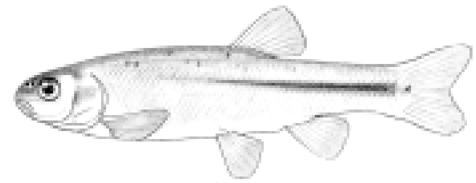


Illustration by: D.A. Neely

Pearl Dace
Margariscus margarita

Life History:

Adult Size: 65-120 mm TL (Lee et al. 1980).

Longevity: 4 years (Fava and Tsai 1974; Jenkins and Burkhead 1994).

Diet: Small crustaceans, aquatic insects, mollusks, small fishes, and plant matter (Stasiak 1978; Jenkins and Burkhead 1994).

Fecundity: Females produce 900-2,140 eggs (Fava and Tsai 1974).

Spawning: In Maryland, spawning occurs from late-April to early June when water temperatures at 13-15°C (Fava and Tsai 1974). Males defend small spawning territories (Langlois 1929).

Habitat: Pearl dace inhabits cold, spring-fed headwater to medium-sized streams. This species is commonly associated with aquatic vegetation (Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Although believed to be once widespread, relict populations of pearl dace are currently restricted to the coldwater, spring-fed portions of the Upper and Middle Potomac River (Fig. A-38).

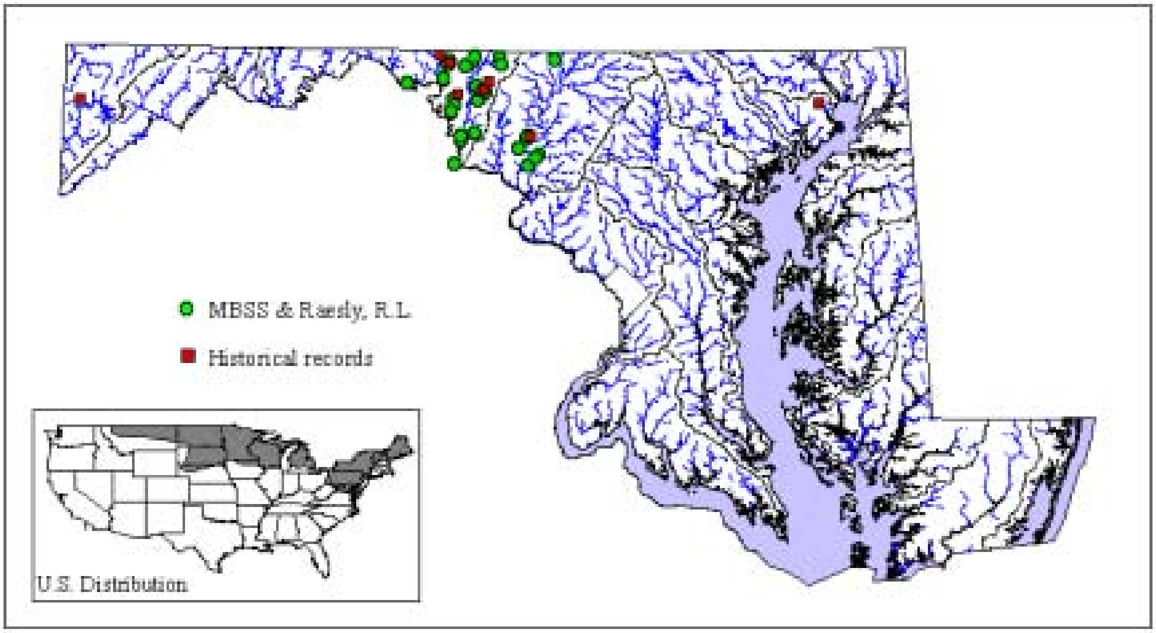


Fig. A-38. Records for pearl dace in Maryland.

Status and Abundance: Pearl dace is considered globally secure, but rare in parts of its range. This species is a GCN species in Virginia. The status of this species, as determined by the Maryland Department of Natural Resources, is Threatened (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 134,983 ± 110,418 pearl dace in Maryland.

Key Habitats: Pearl dace is associated with spring-fed, limestone streams (MDNR 2005). The stronghold watersheds for pearl dace are Antietam Creek, Marsh Run, Lower Monocacy River, Conococheague Creek, Potomac River in Washington County, and the Upper Monocacy River. These watersheds are essential for the conservation of pearl dace in Maryland.

Species Associations: A total of 42 different fish species were present at sites where pearl dace was collected. The five species that most often co-occurred with pearl dace included: blacknose dace, white sucker, fantail darter, longnose dace, and creek chub.

Stressors: Given its restricted distribution and propensity for cold, spring-fed waters, this species is susceptible to stream degradation caused by human disturbance. Pearl dace populations in Maryland are located in predominately agricultural watersheds that are currently experiencing increased pressure associated with urban sprawl (Table A-1).

Groundwater withdrawal and adverse changes in stream temperatures associated with urbanization and agriculture may reduce or degrade the coldwater, spring-fed habitats preferred by this species. Stressors associated with urban development would be expected to have a negative effect on pearl dace populations in these watersheds. Of particular concern to pearl dace conservation is the loss of infiltration and subsequent reduction of springs and stream flows associated with impervious surfaces. Land use change, if continued, could ultimately degrade critical habitats and reduce populations of pearl dace in these watersheds. A list of other stressors in watersheds with pearl dace populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by pearl dace, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-39. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of pearl dace in Maryland requires the protection of spring-fed, limestone habitats. Management that aims to preserve or enhance the connectivity of these habitats will also benefit this species. Restoration of riparian buffers, limits to groundwater withdrawals, and full mitigation of urbanization and management designed to limit impervious surface in stronghold watersheds will benefit populations of pearl dace. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified pearl dace populations in six 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of pearl dace abundances and the extent of pearl dace distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration, and also in areas with spring-fed, limestone habitats preferred by this species. Targeted sampling in these areas may identify currently unknown populations of pearl dace. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of pearl dace populations and critical habitats.

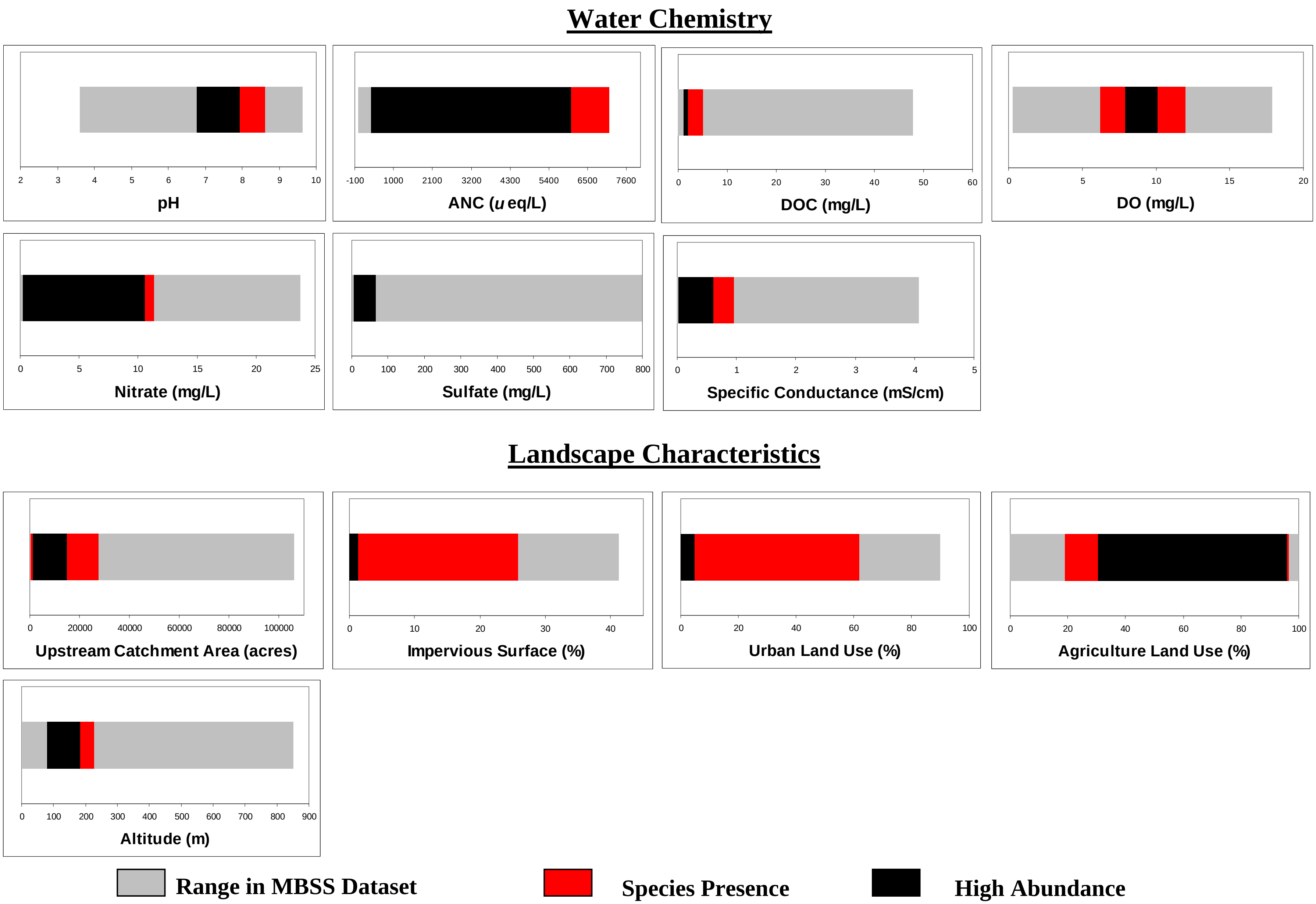


Fig. A-39: Pearl dace range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

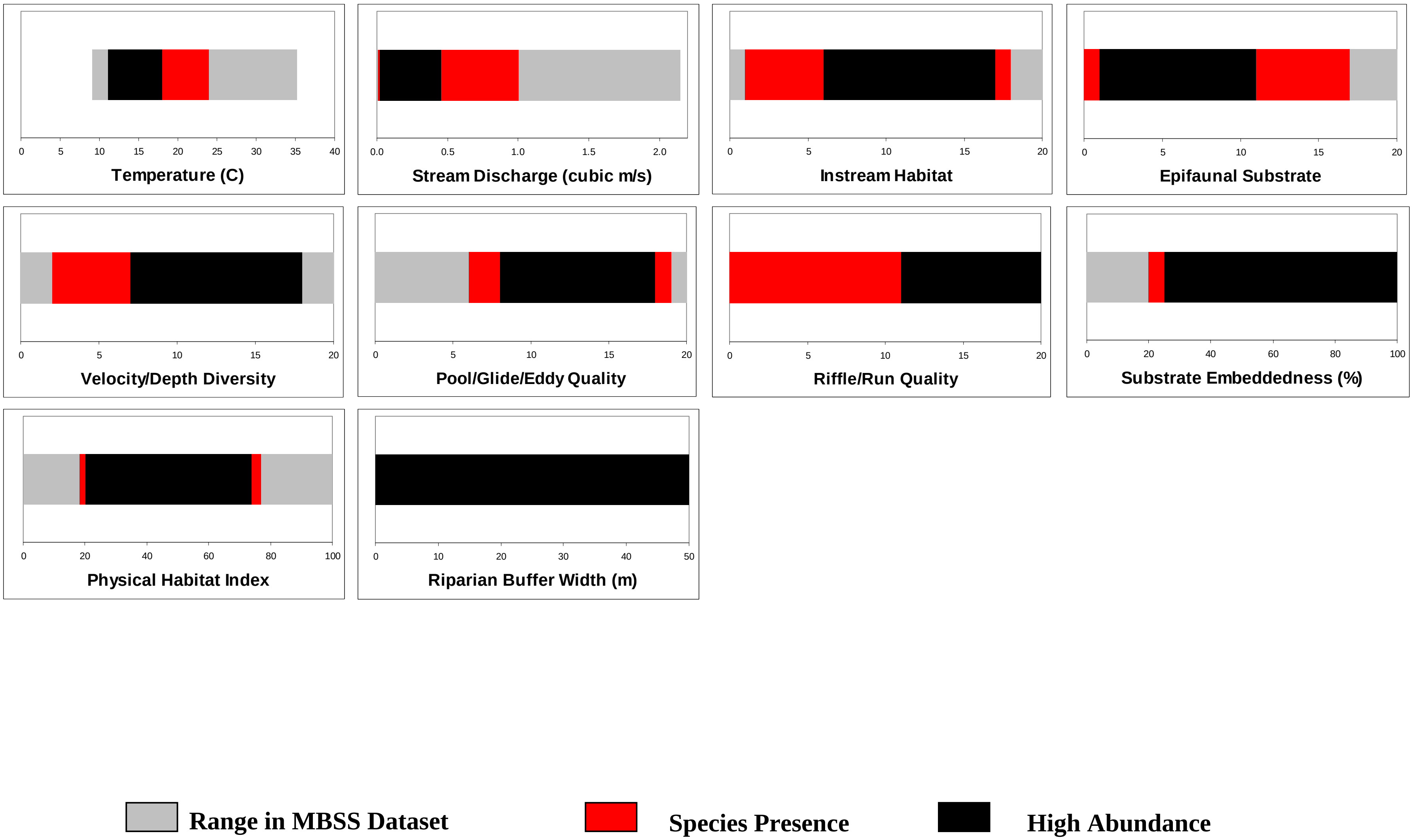
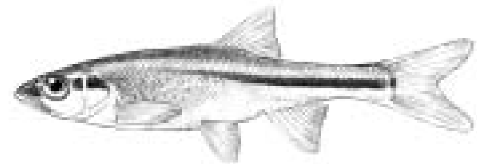


Fig. A-39: continued.



Redside Dace Illustration by: D.A. Neely
Clinostomus elongatus

Life History:

Adult Size: 80 mm SL (Lee et al. 1980).

Longevity: 3-4 years (Lee et al. 1980).

Diet: Primarily aquatic and terrestrial insects (Koster 1939; Schwartz and Norvell 1958; Lee et al. 1980).

Fecundity: Females produce 409-1526 eggs (Koster 1939).

Spawning: Spawning occurs in May in New York in riffles or shallow pools (Koster 1939; Lee et al. 1980).

Habitat: Redside dace inhabits cool, clear small to medium streams with gravel substrate. Redside dace is typically a pool species (Lee et al. 1980).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Redside dace has been collected in the South Branch of Bear Creek in Garrett County, Maryland (Hendricks et al. 1979; Fig. A-40). Prior to this collection of a single specimen, this species was unknown from Maryland. The single specimen from the South Branch of Bear Creek may have been a bait bucket introduction (Hendricks et al.1979).

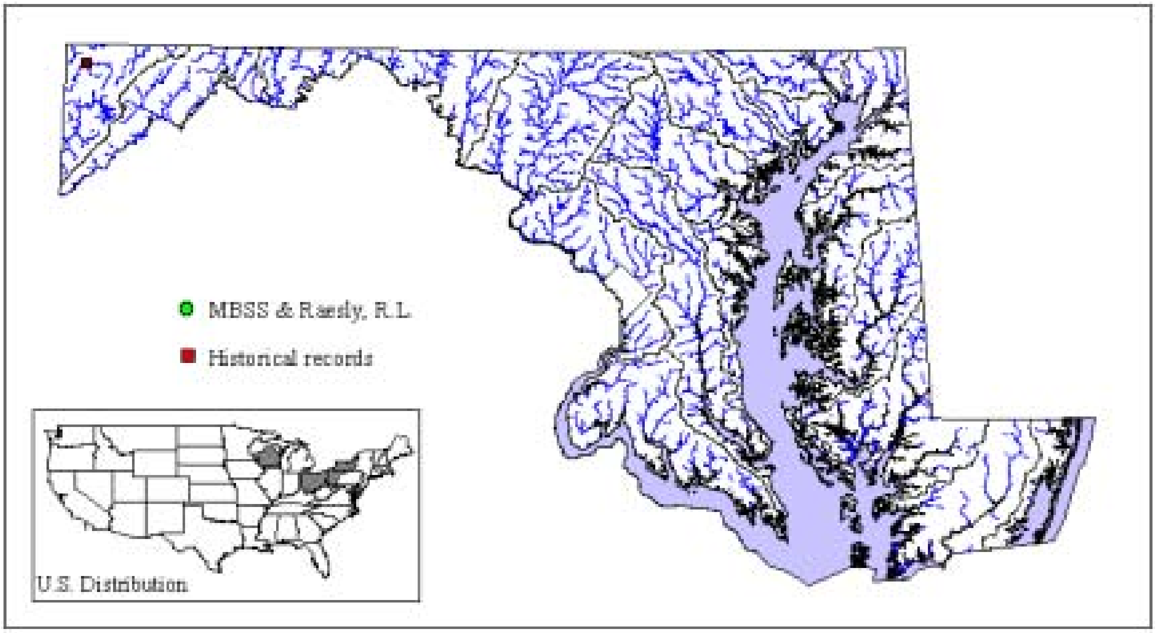
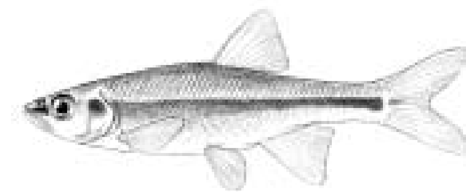


Fig. A-40. Records for redside dace in Maryland.

Status and Abundance: Redside dace is considered globally secure, but rare in parts of its range. In Pennsylvania portions of the Youghiogheny River basin, this species can be locally abundant. The redside dace, as determined by the Maryland Department of Natural Resources, is likely extirpated from Maryland (COMAR 08.03.08).

Monitoring, Planning and Coordination Needs:

Additional sampling surveys of potential habitat in the Youghiogheny River basin are necessary to determine whether or not viable populations of redside dace still reside in Maryland. Targeted sampling should be focused in areas with habitats preferred by redside dace. Targeted sampling in these areas may identify currently unknown populations of this species.



Rosyside Dace Illustration by: D.A. Neely
Clinostomus funduloides

Life History:

Adult Size: 44-92 mm SL (Lee et al. 1980; Jenkins and Burkhead 1994).

Longevity: 4 years (Davis 1972).

Diet: Primarily aquatic insects; also crayfishes, worms, mollusks, algae, and detritus (Breder and Crawford 1922; Flemer and Woolcott 1966; Gatz 1979; Jenkins and Burkhead 1994).

Fecundity: Females produce 121-997 eggs (Davis 1972).

Spawning: Based on Virginia data, spawning occurs from early-April to late-June in water temperatures of 12.7-25.2 °C (Jenkins and Burkhead 1994). Spawning occurs over nests of other minnows *Nocomis* and *Semotilus and Campostoma* (Davis 1972; Jenkins and Burkhead 1994; Etnier and Starnes 1993; Mettee et al. 1996).

Habitat: Rosyside dace inhabits a variety of habitat from cold, mountain high gradient streams to warm, sluggish low gradient streams of the Coastal Plain. This species is typically associated with pool habitat (Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Rosyside dace is widespread in Maryland, with extant populations known from the Elk River, Susquehanna River, Bush River, Gunpowder River, Patapsco River, West Chesapeake Bay, Patuxent River, Lower Potomac River, Potomac Washington Metro, Middle Potomac River, Upper Potomac River, and the North Branch Potomac River drainage basins (Fig. A-41). Although this species is more common in the Piedmont of Maryland, relict populations of rosyside dace are found in portions of the Choptank River and Chester River on Delmarva Peninsula; suggesting a wider lowland distribution prior to the formation of Chesapeake Bay (Jenkins and Burkhead 1994).

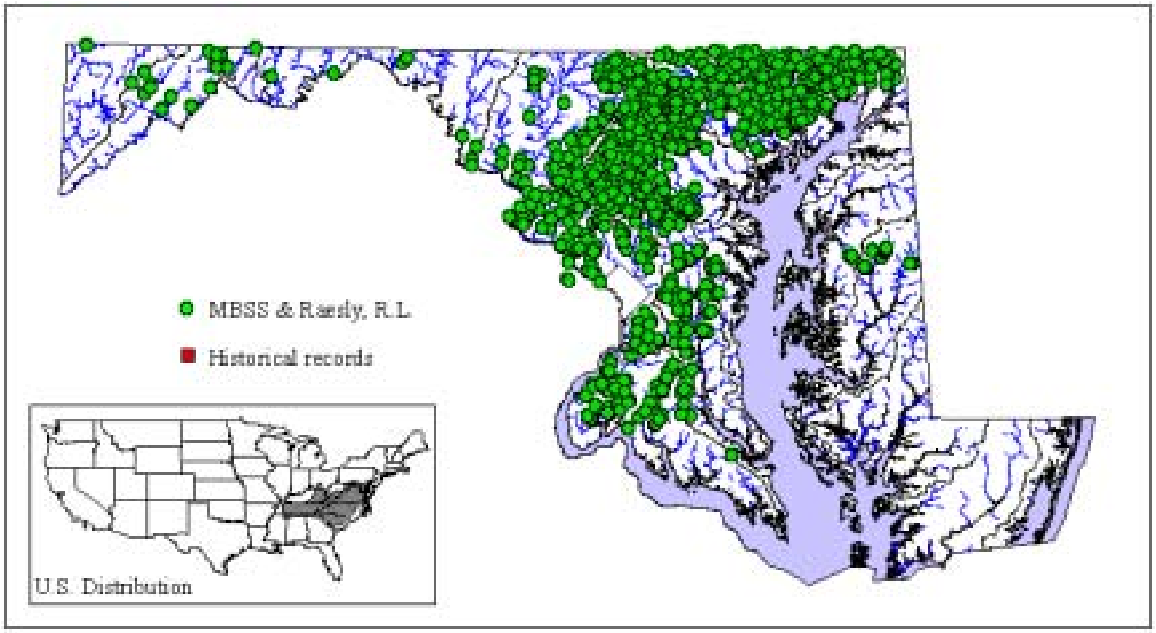


Fig. A-41. Records for rosyside dace in Maryland.

Status and Abundance: Although it is not currently listed as a rare, threatened, or endangered species in Maryland, rosyside dace is considered intolerant to anthropogenic stress (Roth et al. 1997). Based on quantitative MBSS electrofishing data, there are currently an estimated 2,768,643 ± 252,152 rosyside dace in Maryland.

Key Habitats: Rosyside dace is associated Piedmont and Coastal Plain stream types (MDNR 2005). The stronghold watersheds for rosyside dace include Furnace Bay, Northeast River, Atkisson Reservior, Middle Patuxent River, and Deer Creek. These watersheds are essential for the conservation of rosyside dace in Maryland. Upper Choptank River, Corsica River, and Tuckahoe Creek watersheds are essential watersheds for the conservation of rosyside dace populations on Delmarva Peninsula.

Species Associations: A total of 83 different fish species were present at sites where rosyside dace was collected. The five species that most often co-occurred with rosyside dace included: blacknose dace, creek chub, white sucker, tessellated darter, and longnose dace.

Stressors: Given the distribution of rosyside dace in urbanizing and agricultural watersheds in Maryland, stressors and threats to this species vary by watershed. Adverse changes in stream physical habitat, water chemistry, stream temperatures, and stream velocity associated with agriculture and urbanization have reduced or eliminated rosyside dace populations from portions of watersheds in Maryland (Stranko et al. 1995). Extensive urbanization has occurred in Furnace Bay, Northeast River, Atkisson Reservoir, and Middle Patuxent River watersheds (Table A-1). The increase in urban land use coincided with a proportional loss of forested and agricultural lands. Based on the existing state of knowledge about adverse changes in stream temperature, stream water chemistry, stream velocity, and physical habitat quality associated with increasing urbanization, populations of rosyside dace in these watersheds are likely declining. A list of other stressors in watersheds with rosyside dace populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by rosyside dace, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-42. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of rosyside dace in the stronghold watersheds undergoing extensive urbanization. Management aimed to reduce nutrient and pesticide run-off and restore riparian buffers will benefit rosyside dace populations in agricultural watersheds. Soil conservation and best management practices designed to limit channel alteration, stream bank erosion, and stream sedimentation will protect rosyside dace spawning habitats. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified rosyside dace populations in 67 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling will improve our understanding of rosyside dace distribution and abundance, and track changes over time. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of rosyside dace populations and critical habitats.

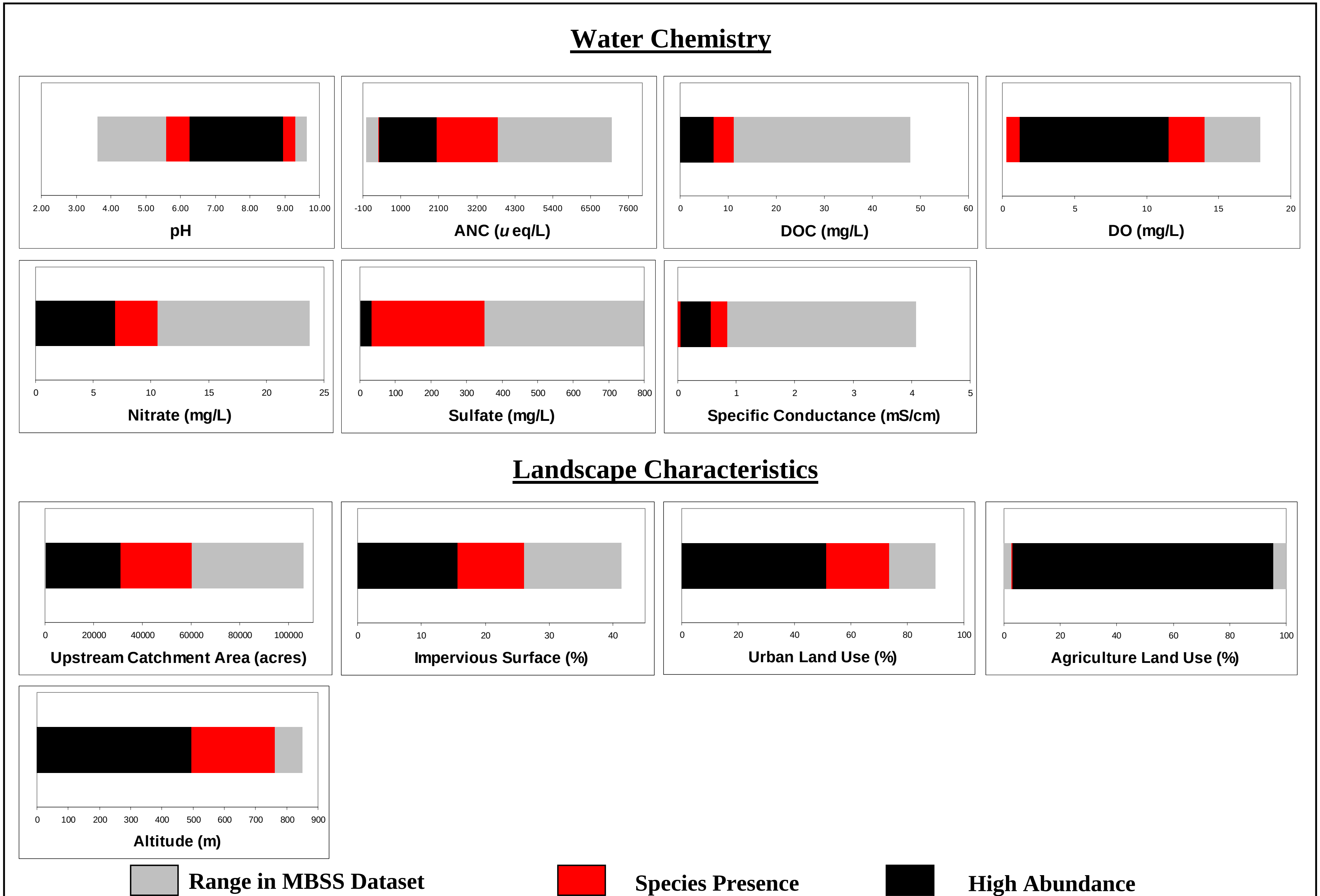


Fig. A-42: Rosyside dace range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

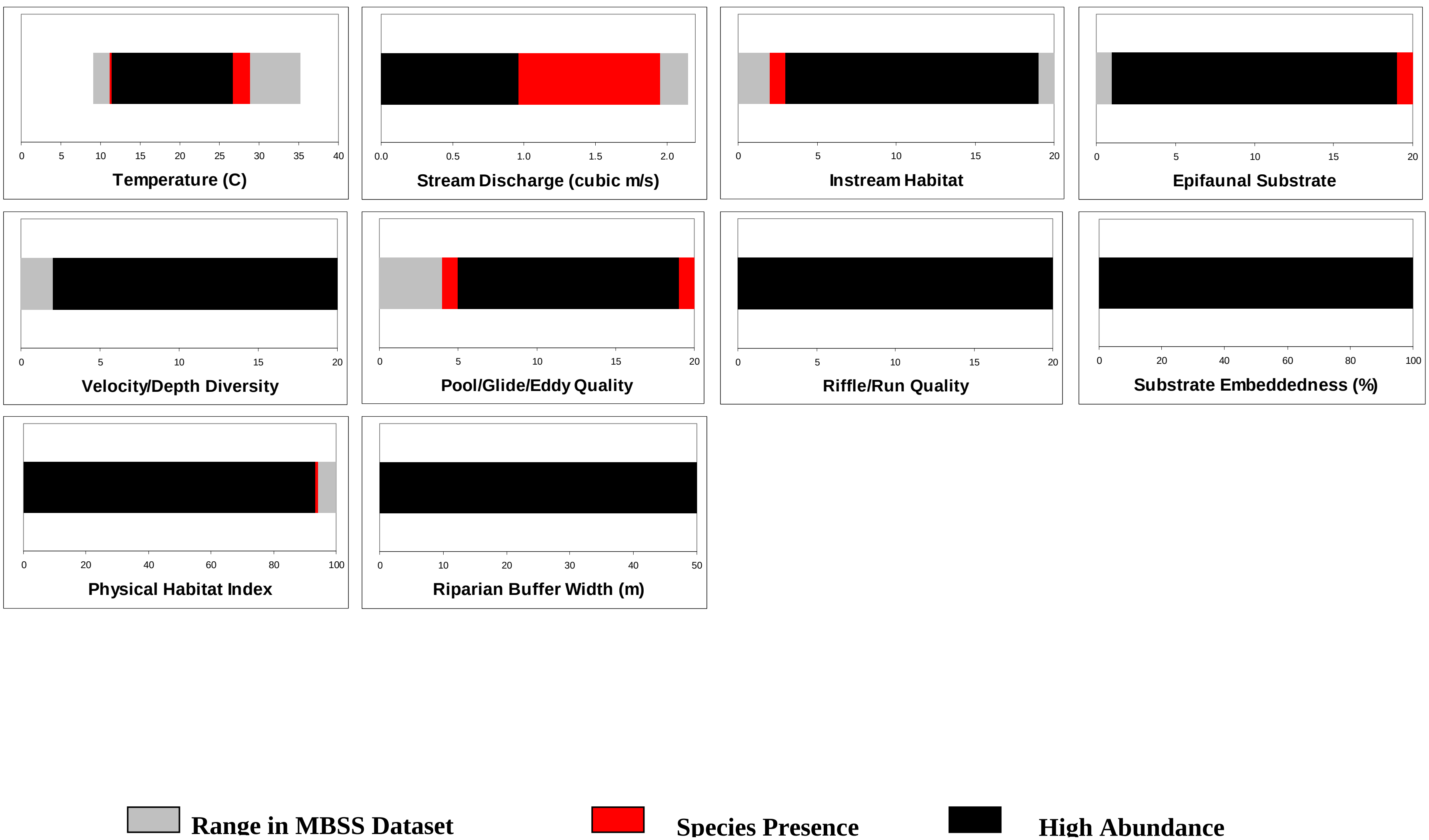


Fig. A-42: continued.

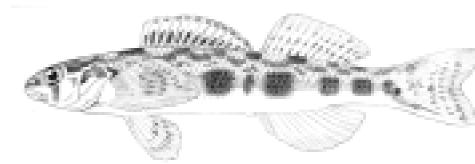


Illustration by: D.A. Neely

Shield Darter
Percina peltata

Life History:

Adult Size: 55-71 mm SL, although length of 75 mm SL has been reported (Jenkins and Burkhead 1994; Page 1983).

Longevity: maximum age of 3 years (Jenkins and Burkhead 1994).

Diet: Primarily insectivorous (Jenkins and Burkhead 1994).

Fecundity: 15-25 eggs (Jenkins and Burkhead 1994).

Spawning: Spawning occurs from late April to early June (Loos and Woolcott 1969; Jenkins and Burkhead 1994) in swift current. This species is reported to bury eggs in silt-free sand and fine gravel substrate of riffles (Loos and Woolcott 1969).

Habitat: Shield darter inhabits low to moderate gradient streams with varied substrates, and seems to prefer swift currents relatively devoid of silt (Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Although shield darter is considered to be one of the most widespread percinids on the Atlantic slope, it is relatively uncommon throughout its range (Jenkins and Burkhead 1994). In Maryland, extant populations of shield darter are known from portions of the Upper Potomac River, Susquehanna River, Gunpowder River, Patapsco River, and Patuxent River drainage basins of the western shore of Chesapeake Bay, and the Choptank and Pocomoke River basins of Delmarva Peninsula (Fig. A-43).

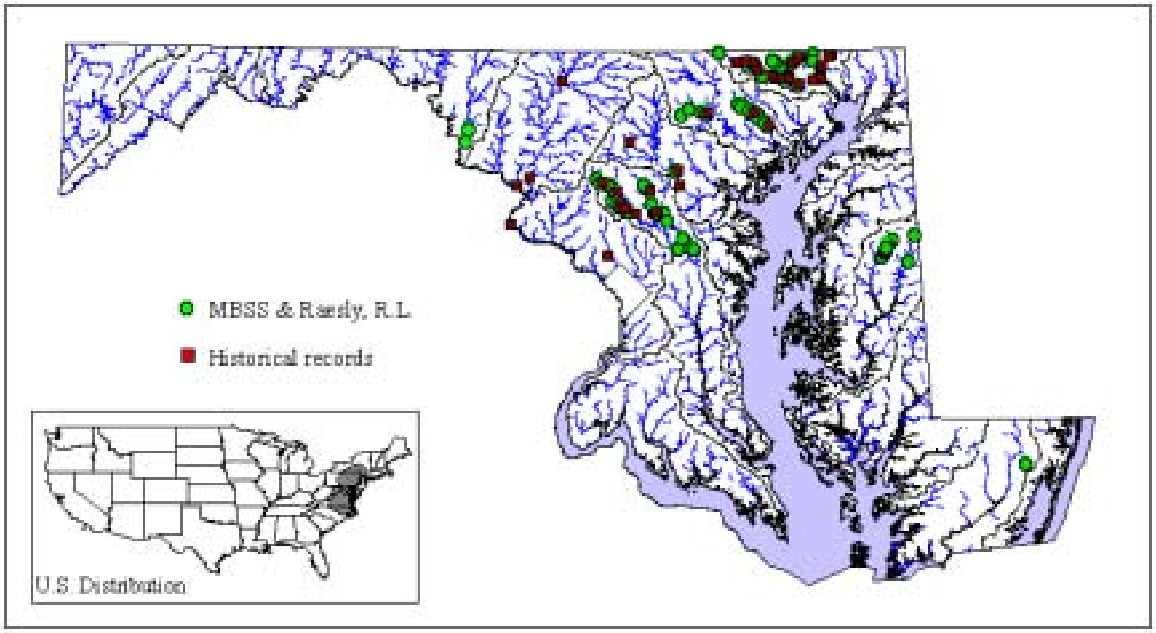


Fig. A-43. Records for shield darter in Maryland.

Status and Abundance: Shield darter is considered a GCN species in Delaware. This species is rare to uncommon in Maryland and is currently on the state "Watch List". Based on quantitative MBSS electrofishing data, there are currently an estimated 60,567 ± 23,125 shield darter in Maryland.

Key Habitats: Shield darter is associated with Piedmont, Blackwater, and Coastal Plain stream types (MDNR 2005). The stronghold watersheds for shield darter include the Middle Patuxent River, Tuckahoe Creek, Rock Gorge Dam, Broad Creek, Conowingo Dam, Deer Creek, Little Gunpowder Falls, Brighton Dam, and the Patapsco River Lower North Branch. These watersheds are essential for the conservation of shield darter in Maryland.

Species Associations: A total of 64 different fish species were present at sites where shield darter was collected. The five species that most often co-occurred with shield darter included: tessellated darter, margined madtom, white sucker, redbreast sunfish, and longnose dace.

Stressors: Shield darter is considered intolerant to anthropogenic stress (Roth et al. 1997). Given the widespread distribution of shield darter in the Piedmont and Coastal Plain of Maryland, stressors to this species vary by watershed. Three of the stronghold watersheds, Middle Patuxent River, Rocky Gorge Dam, and Patapsco River Lower North Branch, have undergone extensive urbanization over the period 1973 to 2000 (Table A-1). Populations of shield darter known from these watersheds are vulnerable to degradation of stream conditions associated with impervious surfaces. The other stronghold watersheds, Tuckahoe Creek, Broad Creek, Conowingo Dam, Deer Creek, Little Gunpowder Falls, and Brighton Dam, experienced a slight increase in urban land use during the same period. Continued urbanization and conversion of forested land for development will likely be detrimental to shield darter populations in these watersheds in the future if left unmitigated. The shield darter is considered intolerant to anthropogenic stress (Roth et al. 1997). The affinity of shield darter for silt-free substrate for spawning lends this species vulnerable to excessive stream sedimentation commonly associated with landscape alteration. A list of other stressors in watersheds with shield darter populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by shield darter, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-44. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of shield darter in Maryland requires the protection of the critical silt-free spawning habitats preferred by this species. Soil conservation and best management practices designed to limit channel alteration, stream bank erosion, and stream sedimentation will protect populations of shield darter in agricultural watersheds. Conservation initiatives aimed at protecting riparian buffers and forested land use in watersheds undergoing urbanization will minimize loss of critical habitats in these watersheds. Additionally, management that aims to preserve or enhance the connectivity of these shield darter habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified shield darter populations in 15 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of shield darter abundance and the extent of shield darter distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable shield darter habitat that have not been previously sampled. Targeted sampling in these areas may to identify currently unknown populations of shield darter. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of shield darter populations and critical habitats.

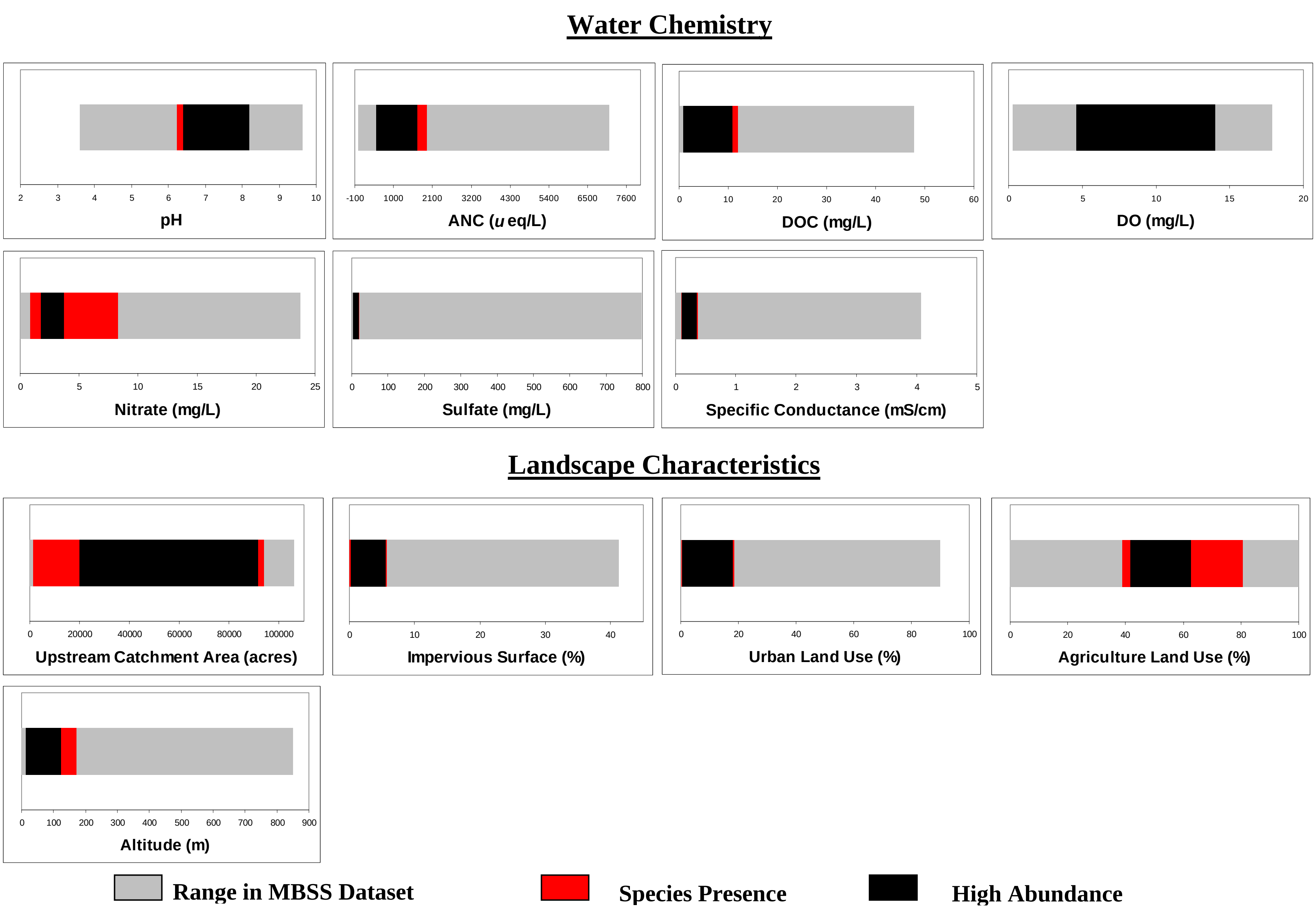


Fig. A-44: Shield darter range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

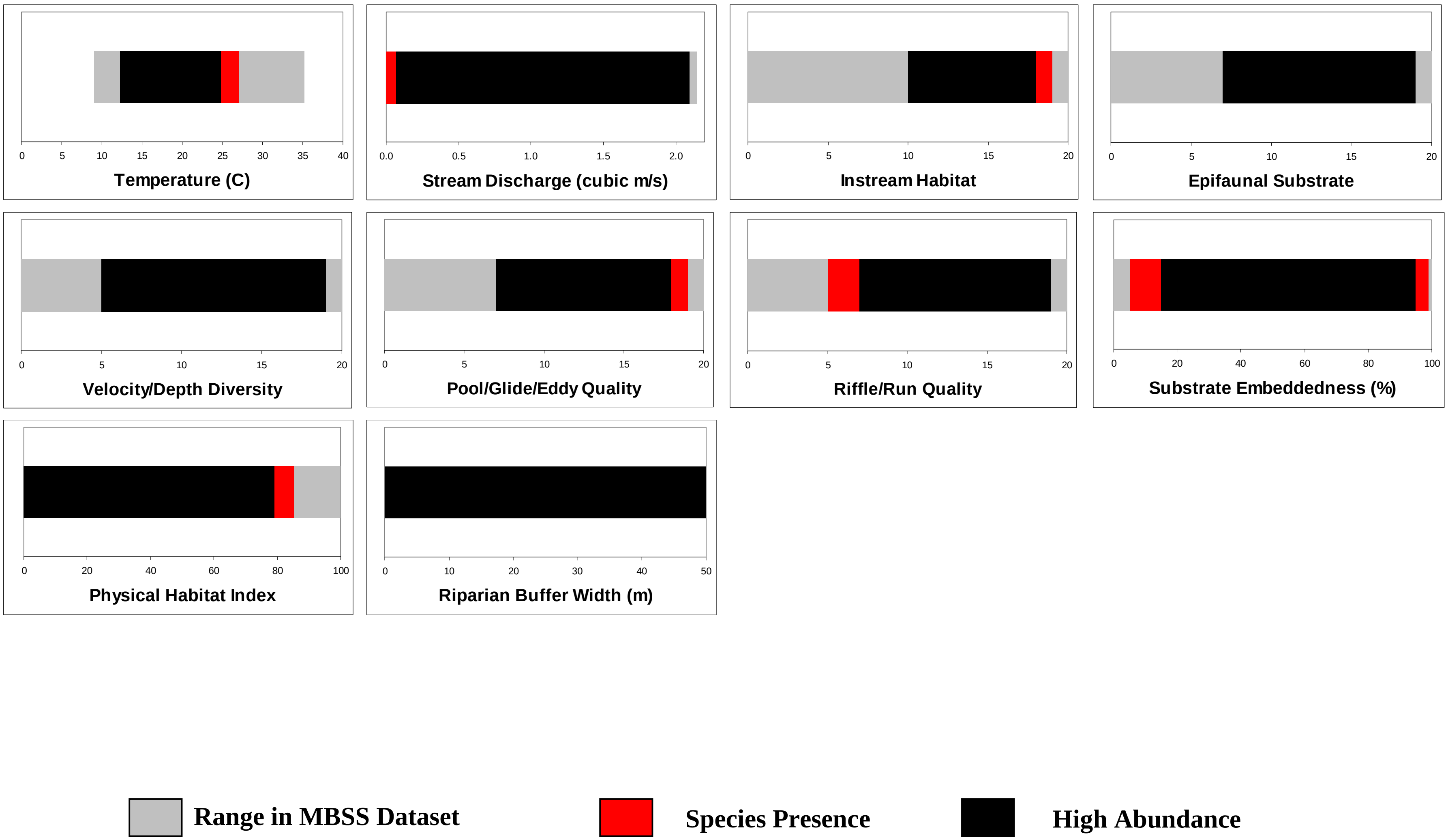


Fig. A-44: continued.

Silverjaw minnow
Notropis buccatus

Illustration by: D.A. Neely

Life History:

Adult Size: 30-45 mm SL, largest Virginia specimen was 69 mm SL (Lee et al. 1980; Jenkins and Burkhead 1994).

Longevity: 3-4 years (Hoyt 1971a, 1971b; Wallace 1971, 1973; Jenkins and Burkhead 1994).

Diet: Benthic worms, small crustaceans, aquatic insects, mollusks, algae, and detritus (Hoyt 1970; Lotrich 1973; Wallace 1976; Jenkins and Burkhead 1994).

Fecundity: Females produce 150-1,350 eggs (Hoyt 1971a; Wallace 1973b).

Spawning: Spawning occurs from March to late-July (Hankinson 1919; Hoyt 1971a; Wallace 1973b; Jenkins and Burkhead 1994).

Habitat: Silverjaw minnow inhabits pool and run habitat in warm, low to moderate gradient streams. This benthic-oriented minnow species is typically associated with clean sand and gravel substrate. Silverjaw minnow commonly aggregate into schools (Lee et al. 1980; Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: In Maryland, silverjaw minnow is distributed predominately in the Piedmont, Blue Ridge, and Valley and Ridge physiographic provinces. Extant populations of silverjaw minnow are known from portions of the Gunpowder River, Patapsco River, Potomac Washington Metro, Middle Potomac River and the Upper Potomac River drainage basins (Fig. A-45).

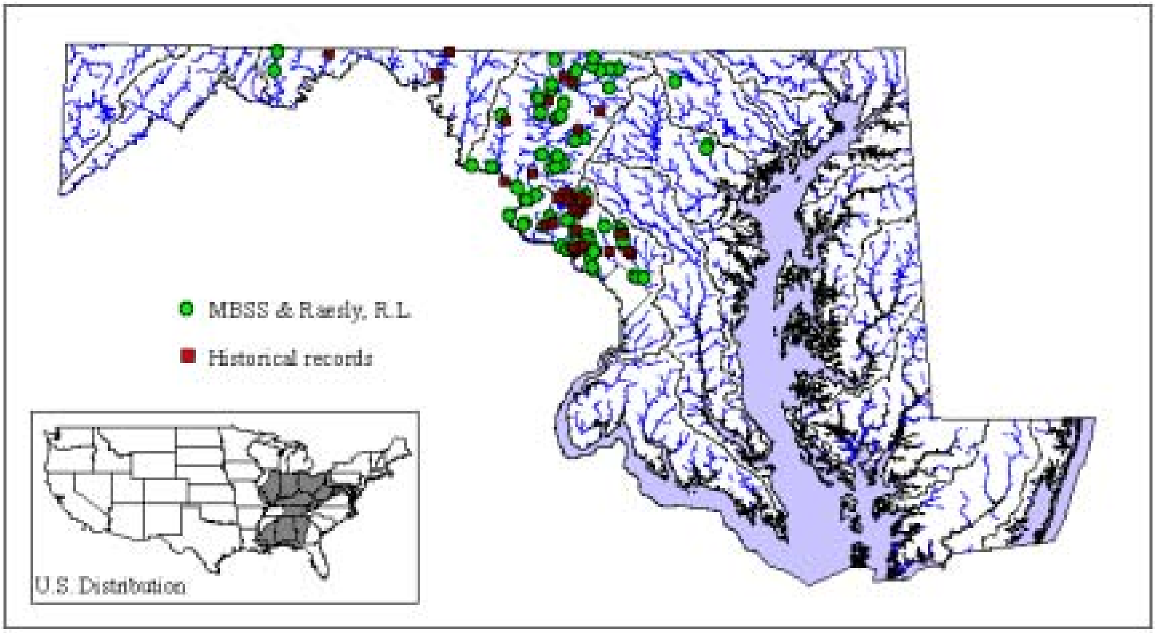


Fig. A-45. Records for silverjaw minnow in Maryland.

Status and Abundance: Although it is not currently listed as a rare, threatened, or endangered species in Maryland, silverjaw minnow has a restricted distribution in the state. Based on quantitative MBSS electrofishing data, there are currently an estimated 515,093 ± 313,406 silverjaw minnow in Maryland.

Key Habitats: Silverjaw minnow is associated with Piedmont and Highland stream types (MDNR 2005). The stronghold watersheds for silverjaw minnow include Cabin John Creek, Potomac River Montgomery County, Upper Monocacy River, Lower Monocacy River, Double Pipe Creek, Seneca Creek, and Anacostia River. These watersheds are essential for the conservation of silverjaw minnow in Maryland.

Species Associations: A total of 58 different fish species were present at sites where silverjaw minnow was collected. The five species that most often co-occurred with silverjaw minnow included: white sucker, blacknose dace, bluntnose minnow, longnose dace, and creek chub.

Stressors: Silverjaw minnow populations in Maryland are located in watersheds undergoing urban development. Five of the stronghold watersheds, Cabin John Creek, Potomac River Montgomery County, Lower Monocacy River, Seneca Creek, and Anacostia River, have undergone extensive urbanization over the period 1973 to 2000 (Table A-1). Populations of silverjaw minnow known from these watersheds are vulnerable to degradation of stream conditions associated with impervious surfaces.

The other stronghold watersheds, Upper Monocacy River and Double Pipe Creek, experienced a slight increase in urban land use during the same period. Continued urbanization and conversion of forested land for development will likely be detrimental to silverjaw minnow populations in these watersheds in the future if left unmitigated. Given its restricted distribution, the silverjaw minnow is vulnerable to adverse changes in stream temperature, stream water chemistry, stream velocity, and physical habitat quality associated with increasing urbanization. The affinity of silverjaw minnow for silt-free substrate lends this species vulnerable to excessive stream sedimentation commonly associated with landscape alteration. A list of other stressors in watersheds with silverjaw minnow populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by silverjaw minnow, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-46. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of silverjaw minnow in Maryland requires the protection of the silt-free habitats preferred by this species. Soil conservation and best management practices designed to limit channel alteration, reduce stream bank erosion, and stream sedimentation will protect populations of silverjaw minnow. Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of silverjaw minnow. Conservation initiatives aimed at protecting riparian buffers and forested land use in watersheds undergoing urbanization will minimize loss of critical habitats in these watersheds. Additionally, management that aims to preserve or enhance the connectivity of these silverjaw minnow habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified silverjaw minnow populations in 13 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling will improve our understanding of silverjaw minnow distribution and abundance, and track changes over time. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of silverjaw minnow populations and critical habitats.

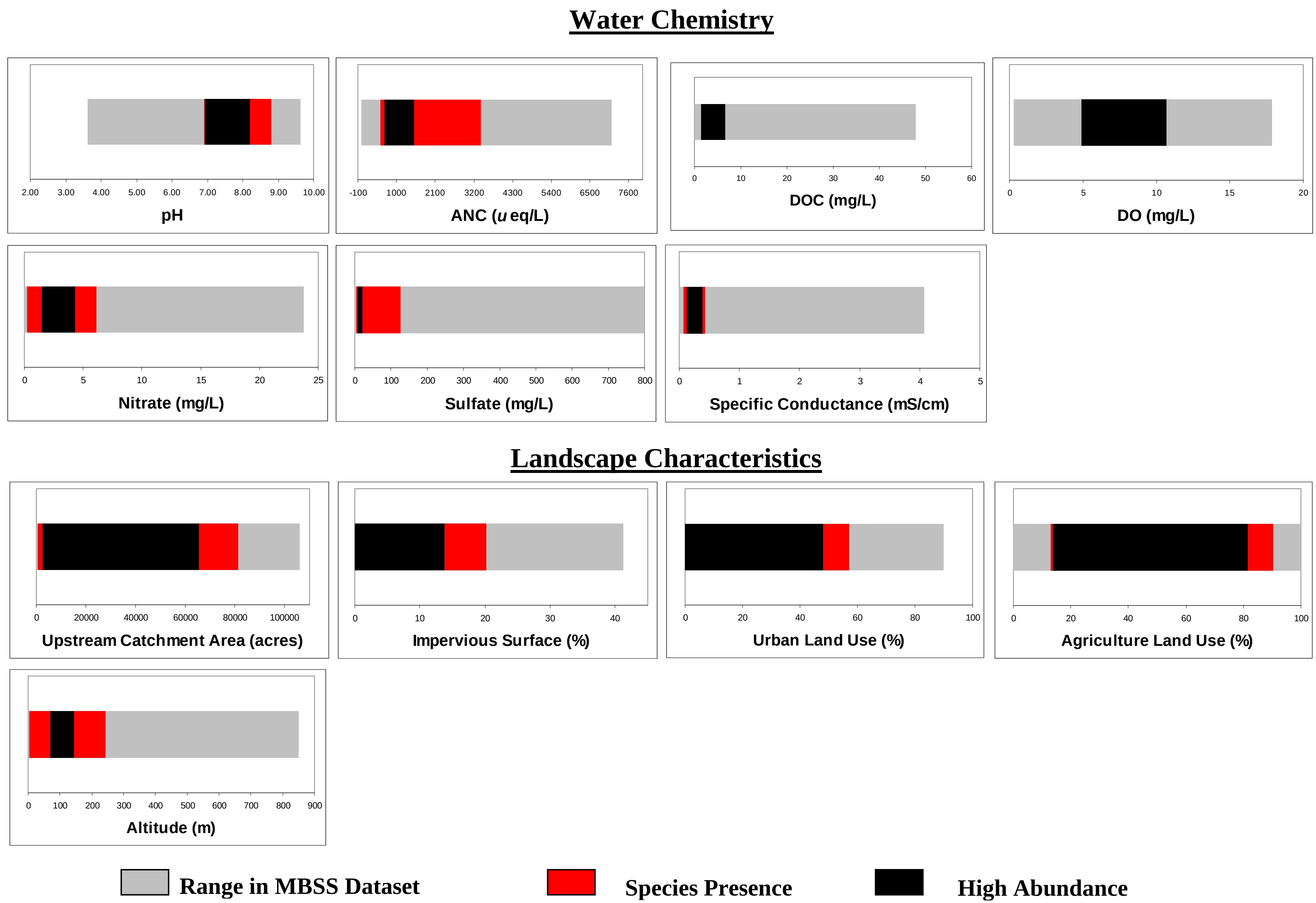


Fig. A-46: Silverjaw minnow range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical

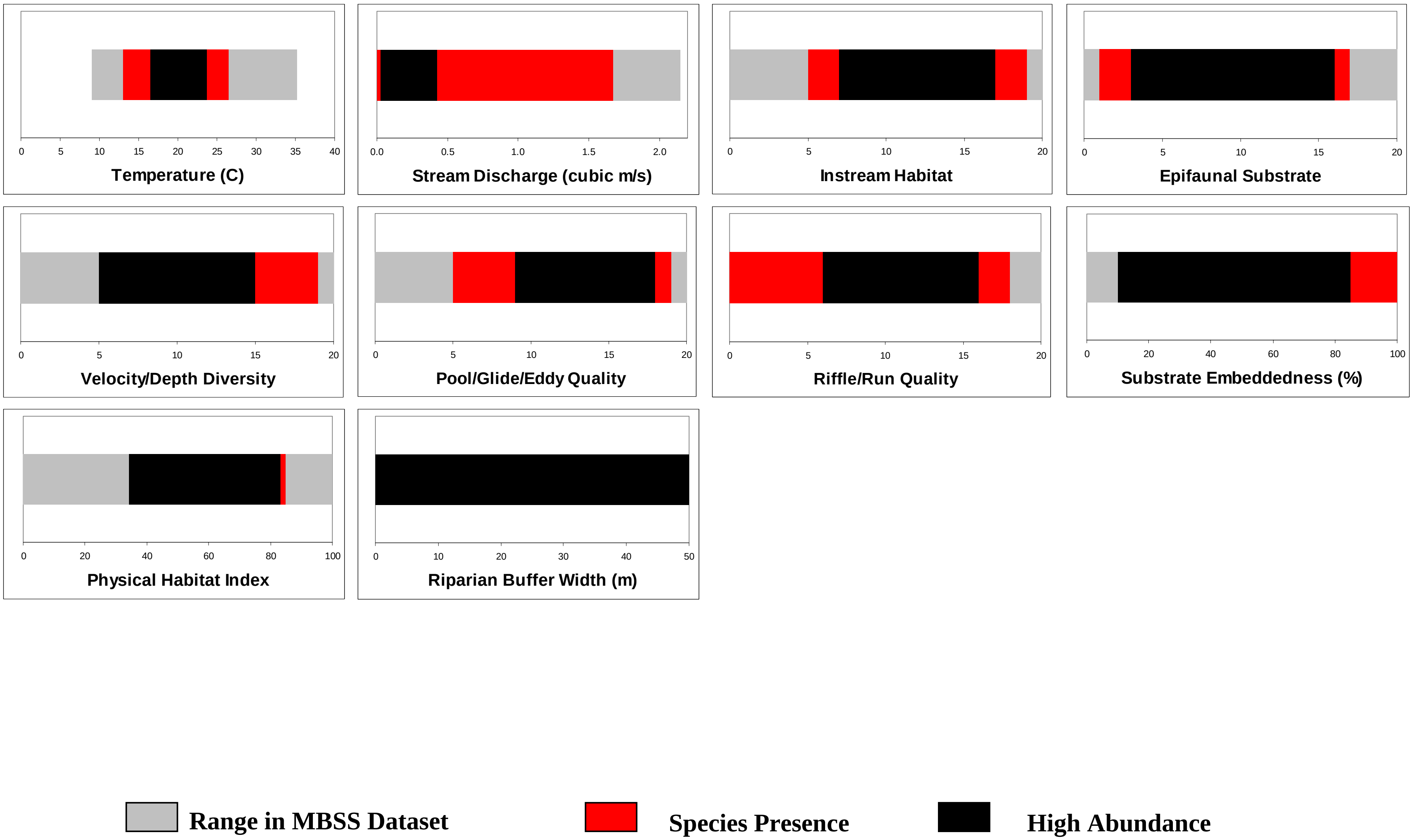
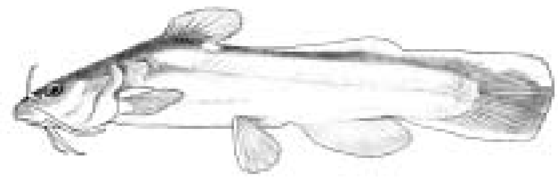


Fig. A-46: continued.



Stonecat
Noturus flavus

Illustration by: D.A. Neely

<u>Life History:</u>

Adult Size: 76-188 mm TL; largest specimen taken from Lake Erie was 312mm (Lee et al. 1980; Trautman 1981; Jenkins and Burkhead 1994)

Longevity: 7-9 years (Walsh and Burr 1985; Etnier and Starnes 1993; Jenkins and Burkhead 1994).

Diet: Aquatic insects, crayfish, and occasionally fishes (Walsh and Burr 1985; Jenkins and Burkhead 1994).

Fecundity: Females produce 189-570 eggs (Greeley 1929; Walsh and Burr 1985; Jenkins and Burkhead 1994).

Spawning: Spawning in occurs from June to August when waters exceed 25 C (Jenkins and Burkhead 1994). Spawning occurs over nests constructed under large rocks in riffle and run habitat. Males guard the nests (Greeley 1929; Walsh and Burr 1985; Jenkins and Burkhead 1994).

<u>Habitat:</u> Stonecat inhabits moderate to low gradient streams and rivers with boulder, bedrock, or rocky substrate. This species prefers riffle and run habitats (Jenkins and Burkhead 1994). In Maryland, stonecat prefers slow to moderate riffle/run habitats with boulder substrate in depths less than 30cm deep (Kline and Morgan 2000).

<u>Migration:</u> Unknown, but adults may make localized movements to preferred spawning habitats.

<u>Distribution and Abundance:</u>

Distribution: Stonecat is restricted to portions of the Youghiogheny River drainage in western Maryland (Fig. A-47).

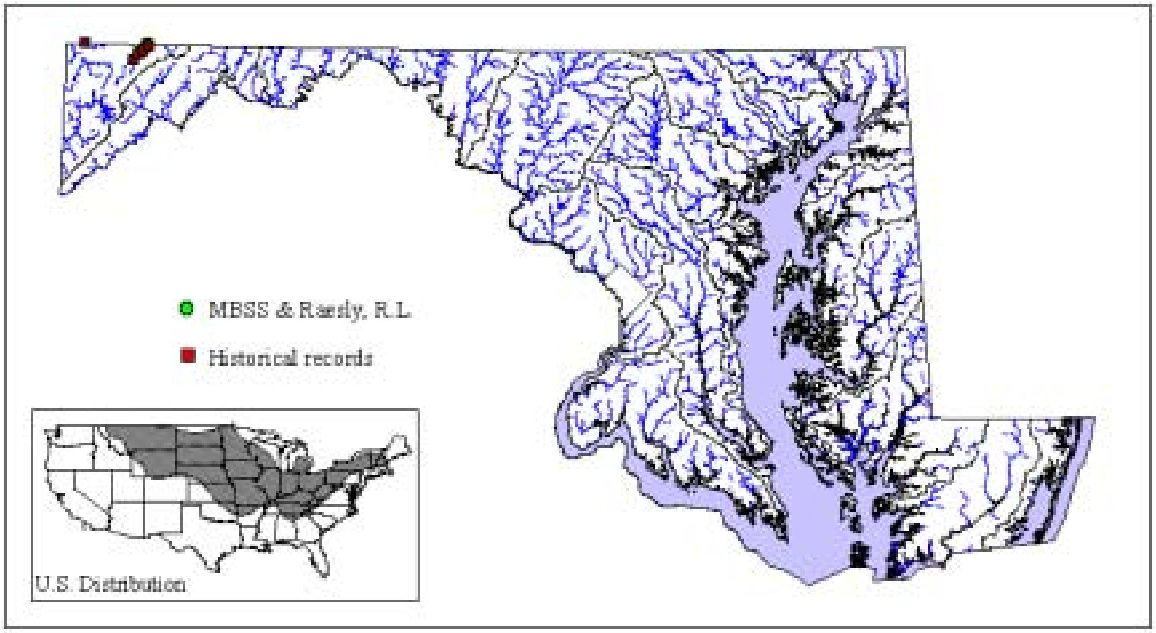


Fig. A-47. Records for stonecat in Maryland.

Status and Abundance: Stonecat is considered globally secure, but rare in parts of its range. This species is a GCN species in Virginia. The status of this species, as determined by the Maryland Department of Natural Resources, is Endangered (COMAR 08.03.08).

Key Habitats: Stonecat is associated with Highland rivers (MDNR 2005). The stronghold watershed for stonecat is the Casselman River. This watershed is essential for the conservation of stonecat in Maryland.

Species Associations: A total of 16 different fish species were present at sites where stonecat was collected. The five species that most often co-occurred with stonecat included: striped shiner, rock bass, white sucker, bluntnose minnow, and smallmouth bass.

Stressors: Stonecat is considered intolerant to anthropogenic stress (Roth et al. 1997). Stonecat populations are restricted to a small portion of the Youghiogheny River basin in Western Maryland. This restricted population makes this species vulnerable to human land use alterations within this basin. The Casselman River watershed experienced slight increases in urban land use during the period of 1973 to 2000 (Table A-1). Land use change, if continued, could ultimately degrade critical habitats and reduce populations in these watersheds. Sedimentation caused by logging, and changes in water chemistry associated with acid mine drainage are stressors to stonecat populations. A list of other stressors in this watershed is shown in Appendix D.

Conservation Actions:

The maintenance of viable populations of stonecat in Maryland requires full mitigation of logging practices and acid mine drainage within the Casselman River. Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of stonecat in the Casselman River watershed. The critical habitat for this species is large substrate in the large river portions of this watershed. Management that aims to preserve or enhance the connectivity of this critical habitat will also benefit this species. A captive breeding program, in conjunction with restoration of suitable stonecat habitat, would also supplement re-establishment of stonecat into areas in which they have been extirpated (e.g. mainstem Youghiogheny River). A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

Annual quantitative sampling, following MBSS protocols, will be useful for tracking trends in stonecat abundance, water quality, and overall quality of physical habitat in Casselman River watershed. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and Garrett County will be necessary for the future conservation of stonecat populations and critical habitats.

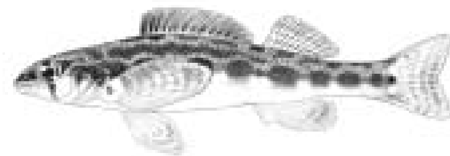


Illustration by: D.A. Neely

Stripeback Darter
Percina notogramma

Life History:

Adult Size: 45-71 mm SL, (Jenkins and Burkhead 1994; Lee et al. 1980).

Longevity: 3 years (Jenkins and Burkhead 1994).

Diet: Primarily insectivorous (Flemer and Woolcott 1966).

Fecundity: unknown.

Spawning: Spawning occurs from late March to early June (Loos and Woolcott 1969; Jenkins and Burkhead 1994) in sluggish current. This species is reported to bury its eggs in bottom substrate (Loos and Woolcott 1969).

Habitat: Stripeback darter inhabits pool, run, and riffle habitats in small to medium-sized streams of moderate gradient (McIninch et al. 1994; Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: This Atlantic slope endemic has a relatively limited distribution ranging from the Patuxent River, Maryland to the James River in Virginia and West Virginia (Jenkins and Burkhead 1994; Lee et al. 1980). Historical records of this species in Maryland exist for tributaries to the Anacostia River and upper portions of the Patuxent River drainage (McIninch et al 1994). This species was believed extirpated from the state until its rediscovery in 1994 (McIninch et al. 1994). Extant populations of stripeback darter are known from two tributaries to Western Branch and portions of the mainstem Western Branch of the Patuxent River (Fig.A-48).

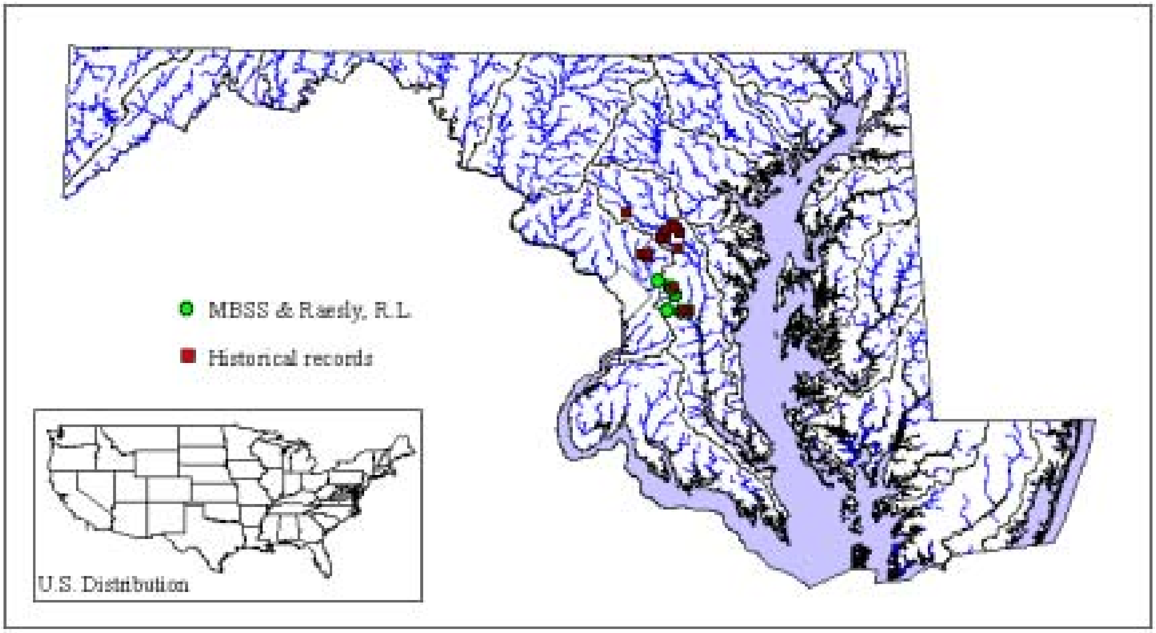


Fig. A-48. Records for stripeback darter in Maryland.

Status and Abundance: Stripeback darter is considered globally secure, but rare in parts of its range. The status of this species, as determined by the Maryland Department of Natural Resources, is Endangered (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 677 ± 647 stripeback darter in Maryland.

Key Habitats: Stripeback darter is associated with Coastal Plain streams (MDNR 2005). The stronghold watershed for stripeback darter is Western Branch. This watershed is essential for the conservation of stripeback darter in Maryland.

Species Associations: A total of 30 different fish species were present at sites where stripeback darter was collected. The five species that most often co-occurred with stripeback darter included: white sucker, tessellated darter, eastern mudminnow, bluegill (non-native), and American eel.

Stressors: Stripeback darter populations in Maryland are located in a watershed undergoing continued urban development. Urbanization has increased substantially in Western Branch watershed during the period of 1973 to 2000 (Table A-1). The increase in urban land use coincided with a proportional loss of forested and agricultural lands. Based on the existing state of knowledge about adverse changes in stream temperature, stream water chemistry, stream velocity, and physical habitat quality associated with increasing urbanization, populations of stripeback darter in Western

Branch are likely declining and continued existence of this species in Maryland is tenuous at best. The ranges of chemical and physical conditions at sites occupied by stripeback darter, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-49. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of stripeback darter in the Western Branch watershed. Additionally, management that aims to preserve or enhance the connectivity of stripeback darter populations will also benefit this species. A captive breeding program, in conjunction with restoration of suitable stripeback darter habitats, would also supplement re-establishment of stripeback darter into portions of Western Branch and the Patuxent River basin in which they have been extirpated. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

Random sampling and targeted surveys of the Western Branch watershed will improve our understanding of stripeback darter abundance and the extent of stripeback darter distributions throughout the watershed. Targeted sampling should be focused in areas not yet sampled, but that likely harbor habitats preferred by this species. Annual quantitative sampling, following MBSS protocols, will be useful for tracking trends in stripeback darter abundance, water quality, and overall quality of physical habitat in Western Branch watershed. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and Prince Georges County will be necessary for the future conservation of stripeback darter populations and critical habitats.

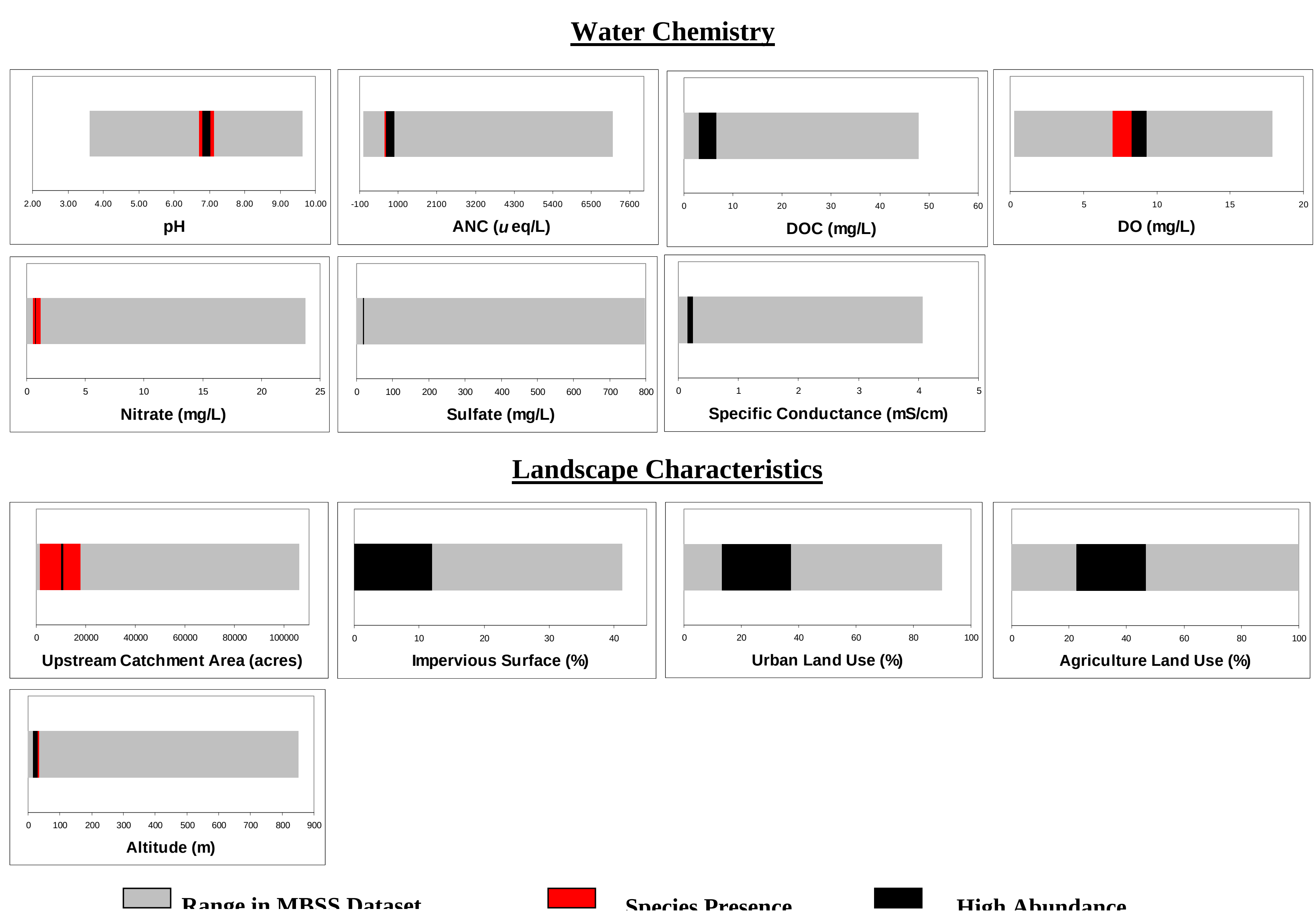


Fig. A-49: Stripeback darter range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

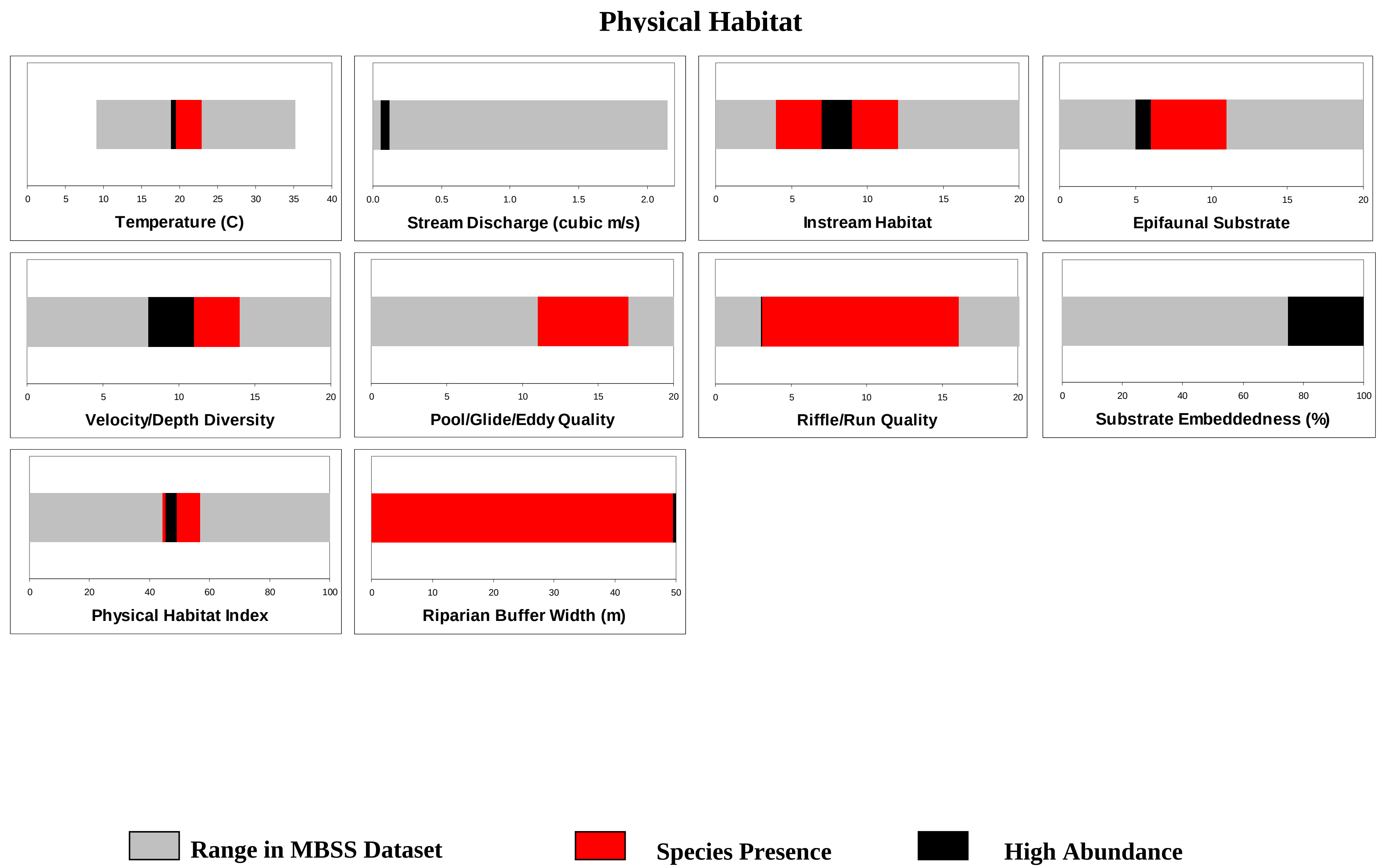
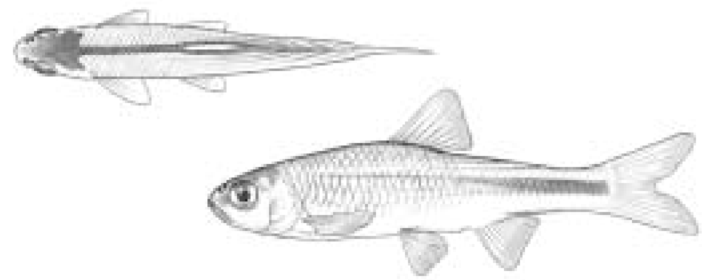


Fig. A-49: continued.



Striped shiner Illustration by: D.A. Neely
Luxilus chrysocephalus

Life History:

Adult Size: 60-143 mm SL (Marshall 1939; Lee et al. 1980; Jenkins and Burkhead 1994).

Longevity: 6 years (Carlander 1969; Jenkins and Burkhead 1994).

Diet: Aquatic insects, small crayfishes, algae, small fishes, and detritus (Gillen and Hart 1980; Angermeier 1985; Jenkins and Burkhead 1994).

Fecundity: Females produce 900-1,150 eggs (Carlander 1969).

Spawning: Spawning occurs from late-May to mid- June when water temperatures at 16-26.7°C in Virginia (Jenkins and Burkhead 1994). Spawning may occur over silt-free gravel, over nests of other species, or in slight depression nests made by males (Etnier and Starnes 1993).

Habitat: Striped shiner inhabits moderate-gradient streams and rivers in pool habitats over various substrates (Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: In Maryland, striped shiner is confined in distribution to portions of the Youghiogheny drainage of western Maryland (Fig. A-50). No populations of striped shiner are known in Atlantic slope drainages of Maryland.

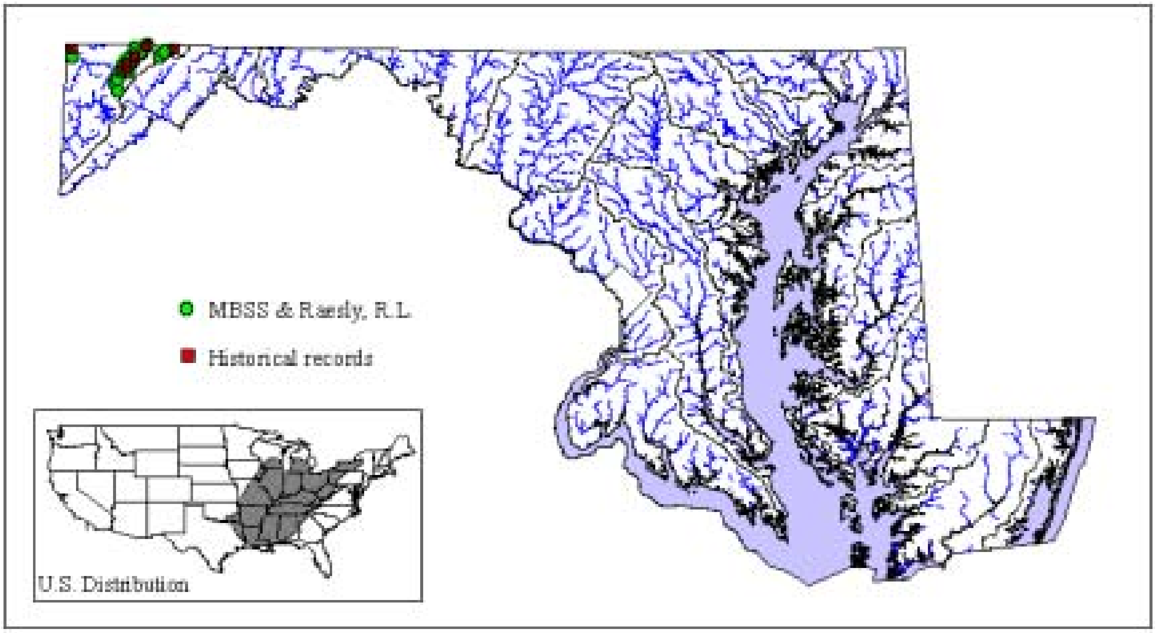


Fig. A-50. Records for striped shiner in Maryland.

Status and Abundance: Striped shiner is considered globally secure. The status of this species, as determined by the Maryland Department of Natural Resources, is In Need of Conservation (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 190 ± 190 striped shiner in Maryland.

Key Habitats: Striped shiner is associated with the Highland streams of the Youghiogheny River basin in Western Maryland (MDNR 2005). The stronghold watersheds for striped shiner include the Casselman River and the Youghiogheny River. These watersheds are essential for the conservation of striped shiner in Maryland.

Species Associations: A total of 36 different fish species were present at sites where striped shiner was collected. The five species that most often co-occurred with striped shiner included: creek chub, white sucker, blacknose dace, mottled sculpin, and johnny darter.

Stressors: Striped shiner populations are restricted to the Youghiogheny River basin in Western Maryland. The limited distribution and the affinity of striped shiner for silt-free substrate for spawning lends this species vulnerable to excessive stream sedimentation commonly associated with landscape alteration. Sedimentation caused by logging, and changes in water chemistry associated with acid mine drainage are stressors within the stronghold watersheds of this species. Urbanization increased slightly in both stronghold watersheds during the period of 1973 to 2000 (Table A-1). Land use change, if continued, could ultimately degrade critical habitats and reduce populations in these watersheds. A list of other stressors in watersheds with striped shiner populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by striped shiner, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-51. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of striped shiner in Maryland requires full mitigation of logging practices and acid mine drainage and the protection of silt-free spawning habitats within the Youghiogheny River basin. Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of striped shiner in the Casselman River and Youghiogheny River watersheds. Soil conservation and best management practices designed to limit channel alteration, stream bank erosion, and stream sedimentation will minimize loss of critical habitats in these watersheds. Management that aims to preserve or enhance the connectivity of striped shiner habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

Targeted surveys by Raesly and Kazyak (2004) of the Youghiogheny River basin have improved our understanding of striped shiner abundance and the extent of striped shiner distributions. Additional targeted sampling should be focused in areas pinpointed for protection and restoration, and also in areas with suitable striped shiner habitat that have not been previously sampled. Annual quantitative sampling, following MBSS protocols, will be useful for tracking trends in striped shiner abundance, water quality, and overall quality of physical habitat in Casselman and Youghiogheny River watersheds. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and Garrett County will be necessary for the future conservation of striped shiner populations and critical habitats.

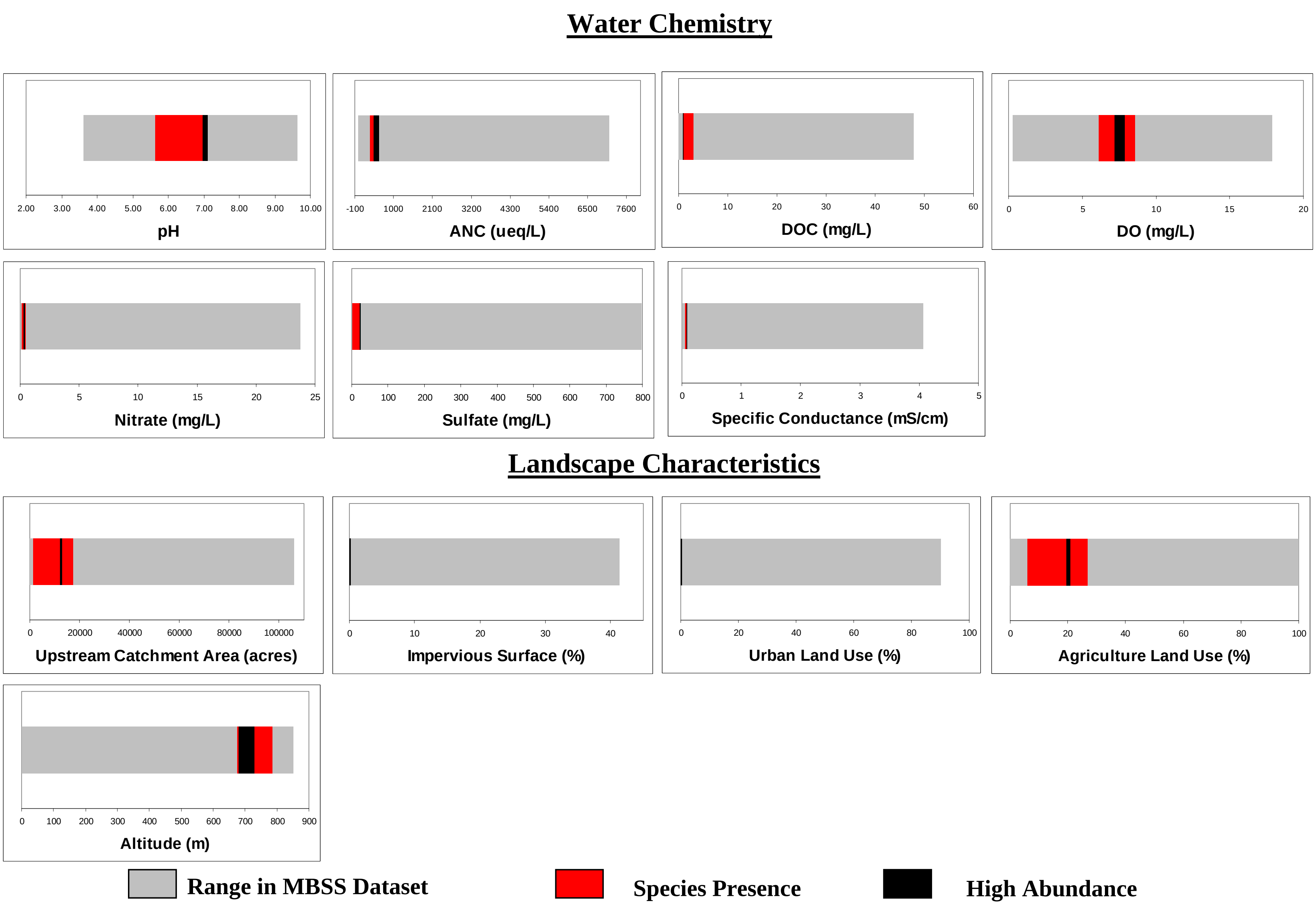


Fig. A-51: Striped shiner range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

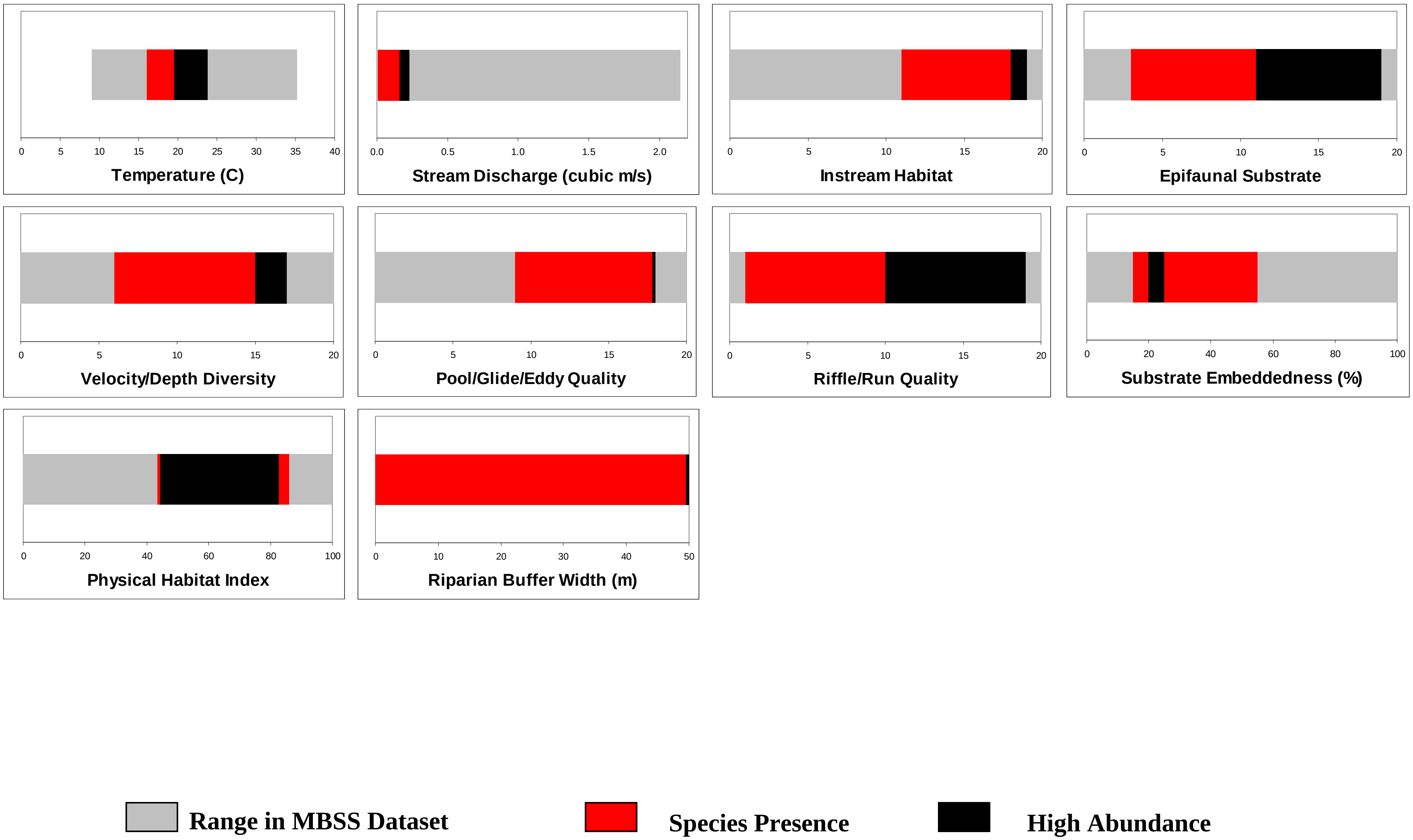
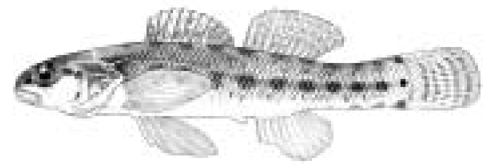


Fig. A-51: continued.



Swamp Darter Illustration by: D.A. Neely
Etheostoma fusiforme

Life History:

Adult Size: 30-50 mm SL (Lee et al. 1980).

Longevity: Less than 2 years (Schmidt and Whitworth 1979; Clemmons and Lindquist 1983).

Diet: Small insects and other invertebrates (Jenkins and Burkhead 1994).

Fecundity: unknown.

Spawning: Spawning occurs from late March to June (Jenkins and Burkhead 1994). Eggs are attached to the surface of various substrates.

Habitat: Swamp darter inhabits low gradient, slow-moving swamps and streams with substrate consisting of sand, silt, woody debris, and detritus. This species can withstand low concentrations of oxygen and somewhat acidic waters (Jenkins and Burkhead 1994).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Although found in the Piedmont of Virginia, swamp darter is confined to the Coastal Plain of Maryland. Extant populations of swamp darter are known from portions of the Lower Potomac River on the western shore of Chesapeake Bay, and the Chester River, Choptank River, Nanticoke/Wicomico River, and Pocomoke River drainage basins on Delmarva Peninsula (Fig. A-52).

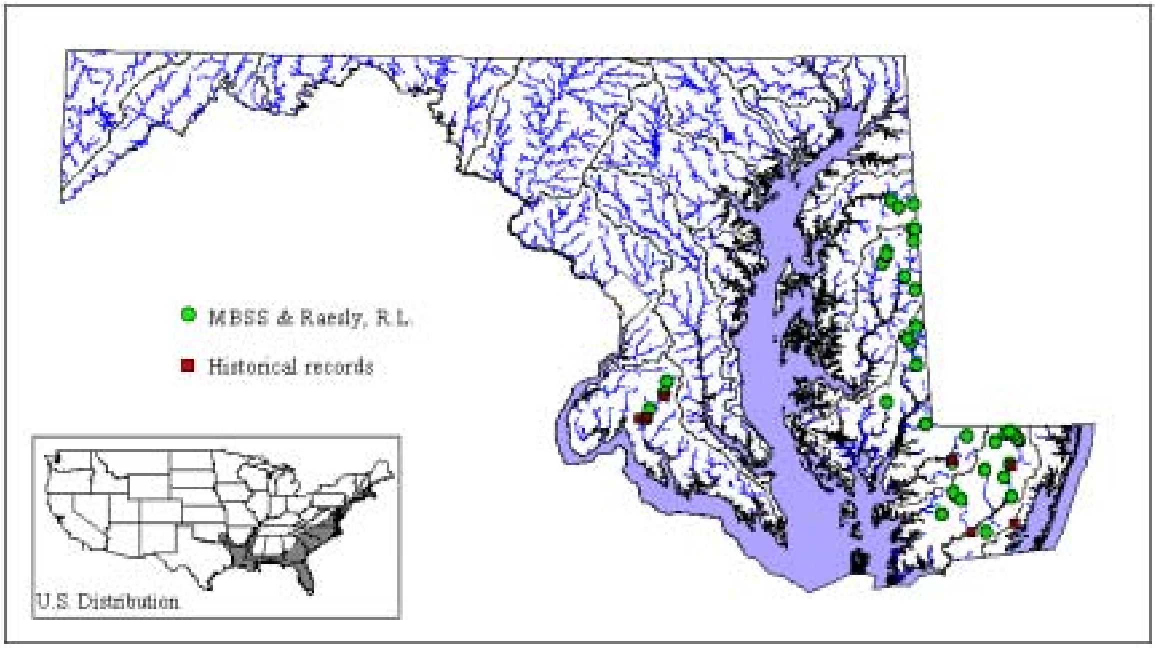


Fig. A-52. Records for swamp darter in Maryland.

Status and Abundance: Swamp darter is considered globally secure, but rare in parts of its range. Swamp darter is a GCN species in Pennsylvania, Virginia, and Delaware. The status of this species, as determined by the Maryland Department of Natural Resources, is In Need of Conservation (COMAR 08.03.08). Based on quantitative MBSS electrofishing data, there are currently an estimated 9,734 ± 3,742 swamp darter in Maryland.

Key Habitats: Swamp darter is associated with Blackwater and Coastal Plain streams (MDNR 2005). The stronghold watersheds for swamp darter include Dividing Creek, Upper Pocomoke River, Nassawango Creek, Transquaking River, Lower Pocomoke River, and Marshyhope Creek. These watersheds are essential for the conservation of swamp darter in Maryland.

Species Associations: A total of 38 different fish species were present at sites where swamp darter was collected. The five species that most often co-occurred with swamp darter included: pirate perch, eastern mudminnow, American eel, redfin pickerel, and creek chubsucker.

Stressors: Swamp darter is considered intolerant to anthropogenic stress (Roth et al. 1997). Swamp darter populations in Maryland are located in primarily agricultural watersheds. Practices associated with agriculture, such as stream channelization, application of fertilizers and pesticides, removal of riparian zones, and the application of lime may reduce or degrade the swampy, slow-water habitats preferred by this species. Each of the six stronghold watersheds for this species has experienced slight increase in urban land use from 1973 to 2000 (Table A-1). Land use change, if continued, could ultimately degrade critical habitats and reduce populations in these watersheds. A list of other stressors in watersheds with swamp darter populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by swamp darter, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-53. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of swamp darter in Maryland requires the protection of critical habitats. Restoration of riparian buffers and the reduction (or full elimination) of stream channelization will serve to protect these habitats. Additionally, management that aims to preserve or enhance the connectivity of swamp darter habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified swamp darter populations in fourteen 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling and targeted surveys at finer spatial scales will improve our understanding of swamp darter abundance and the extent of swamp darter distributions in watersheds in which they are known to occur. Targeted sampling should be focused in areas pinpointed for protection and restoration and in areas with suitable swamp darter habitat that have not been previously sampled. Targeted sampling in these areas may identify currently unknown populations of swamp darter. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of swamp darter populations and critical habitats.

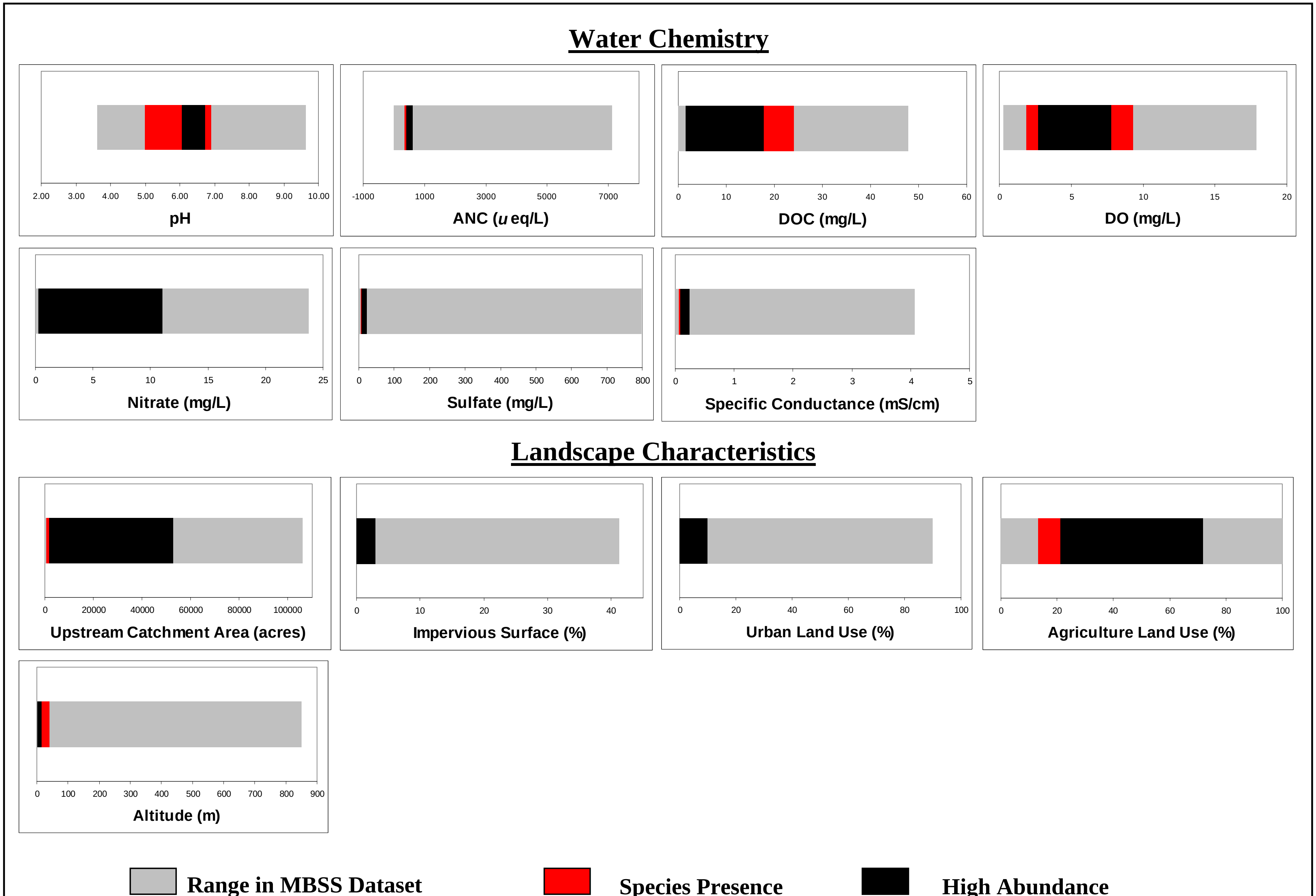
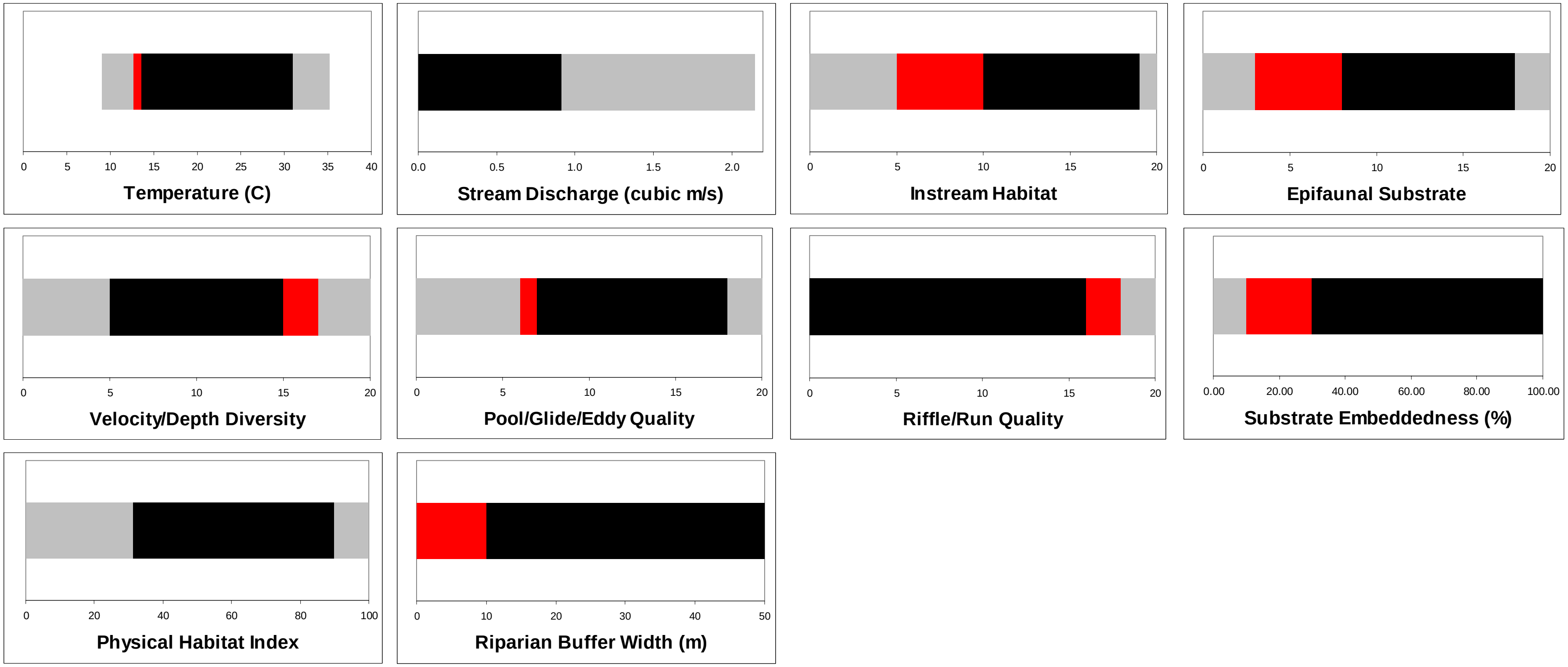


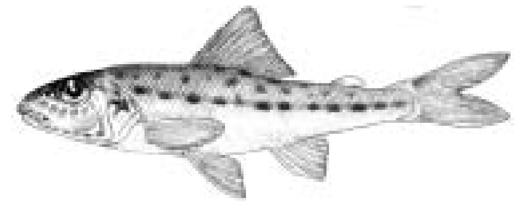
Fig. A-53: Swamp darter range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat



Range in MBSS Dataset **Species Presence** **High Abundance**

Fig. A-53: continued.



Trout-perch Illustration by: D.A. Neely
Percopsis omiscomaycus

Life History:

Adult Size: 60-152 mm TL (House and Wells 1973; Becker 1983; Jenkins and Burkhead 1994).

Longevity: 8 years (House and Wells 1973).

Diet: Aquatic insects, small crustaceans, mollusks, algae, and small fish on occasion (Clemens et al. 1923; Jenkins and Burkhead 1994).

Fecundity: Females produce 126-1,329 eggs (Magnuson and Smith 1963; Muth and Tarter 1975).

Spawning: From data on a Kentucky stream population, spawning of trout-perch takes place from late-April to May in water temperatures above 15 C in riffle habitat (Muth and Tarter 1975). This species is a nocturnal, communal spawner (Magnuson and Smith 1963).

Habitat: Trout-perch prefers deep areas of large streams and rivers (Magnuson and Smith 1963; Jenkins and Burkhead 1994). In northern populations, the trout-perch is common in lakes (Jenkins and Burkhead 1994).

Migration: Unknown, but adults likely make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: In Maryland, trout-perch is known from several locations in the Potomac River near Washington, D.C. and from the Susquehanna River above Susquehanna Flats (Uhler, and Lugger 1876; Schwartz 1964; Lee et al. 1981). The last reported collection of trout-perch in the Potomac River was made in 1911 (Schwartz 1964; Fig A-55).

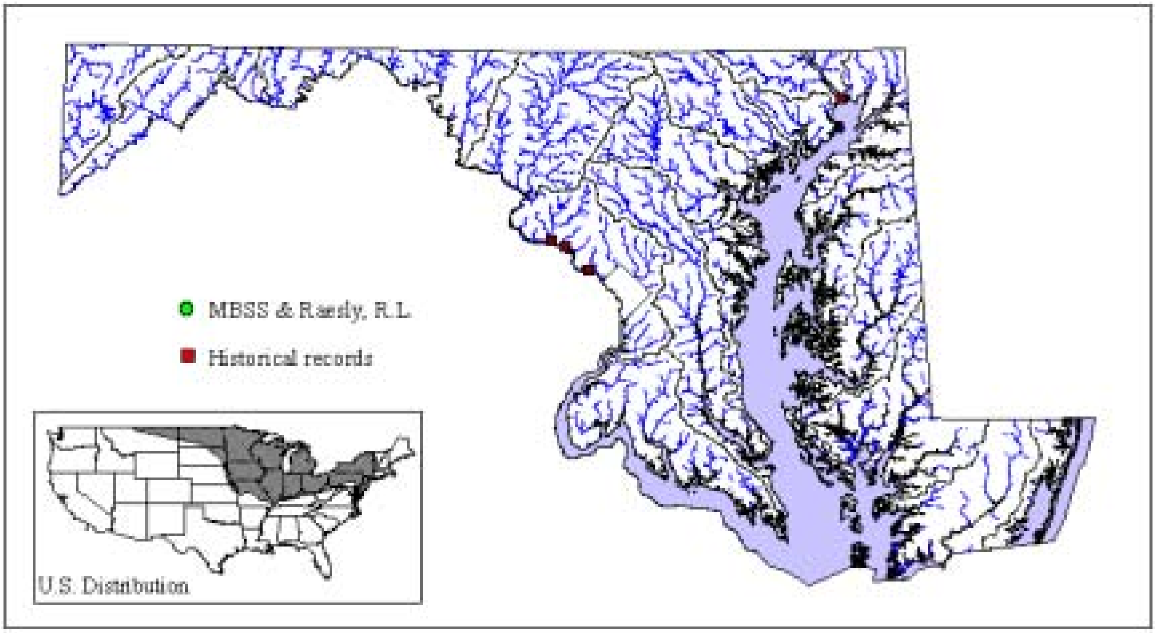
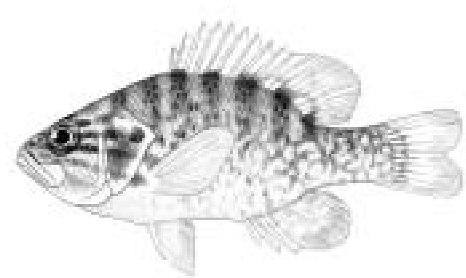


Fig. A-54. Records for trout-perch in Maryland.

Status and Abundance: The status of trout-perch, as determined by the Maryland Department of Natural Resources, is Endangered Extirpated (COMAR 08.03.08).

Monitoring, Planning and Coordination Needs:

Trout-perch has not been collected in Maryland since 1911. Despite recent surveys (Raesly 1998), there are no known populations of trout-perch within the state. Beyond random sampling by the MBSS, no additional monitoring is justified at this time.



Warmouth Illustration by: D.A. Neely
Lepomis gulosus

Life History:

Adult Size: 75- 260 mm TL; specimen reaching 287mm TL was reported from Oregon (Carlander 1977; Norman 1973; Lee et al. 1980; Jenkins and Burkhead 1994)

Longevity: 6-8 years (Jenkins and Burkhead 1994; Mettee et al. 1996).

Diet: Young feed on plankton and small insects. Adults feed on aquatic insects, snails, crayfishes, and fishes (Larimore 1957; Flemer and Woolcott 1966; Gatz 1979; Lee et al. 1980; Jenkins and Burkhead 1994).

Fecundity: 4,500-63,200 eggs per female (Larimore 1957).

Spawning: Spawning period ranges from mid-May to August (Larimore 1957; Lee et al. 1980; Jenkins and Burkhead 1994). Spawning period in Maryland is unknown. Nesting usually occurs near cover. Males guard nests (Carlander 1977; Lee et al. 1980; Jenkins and Burkhead 1994).

Habitat: Warmouth occupies slow-moving pool habitats of streams and rivers, and are commonly found in natural and man-made ponds, lakes, and impoundments (Lee et al. 1980; Jenkins and Burkhead 1994). This species is frequently associated with aquatic vegetation, rootwads, and woody debris (Jenkins and Burkhead 1994; Mettee et al. 1996). This species is known to tolerate low pH waters and low salinities (Musick 1972; Lee et al. 1980; Jenkins and Burkhead 1994; Mettee et al. 1996).

Migration: Unknown, but adults may make localized movements to preferred spawning habitats.

Distribution and Abundance:

Distribution: Extant populations of warmouth are known from portions of the Upper Potomac River, Lower Potomac River, Patuxent River, Elk River, and Chester River drainage basins (Fig. A-55).

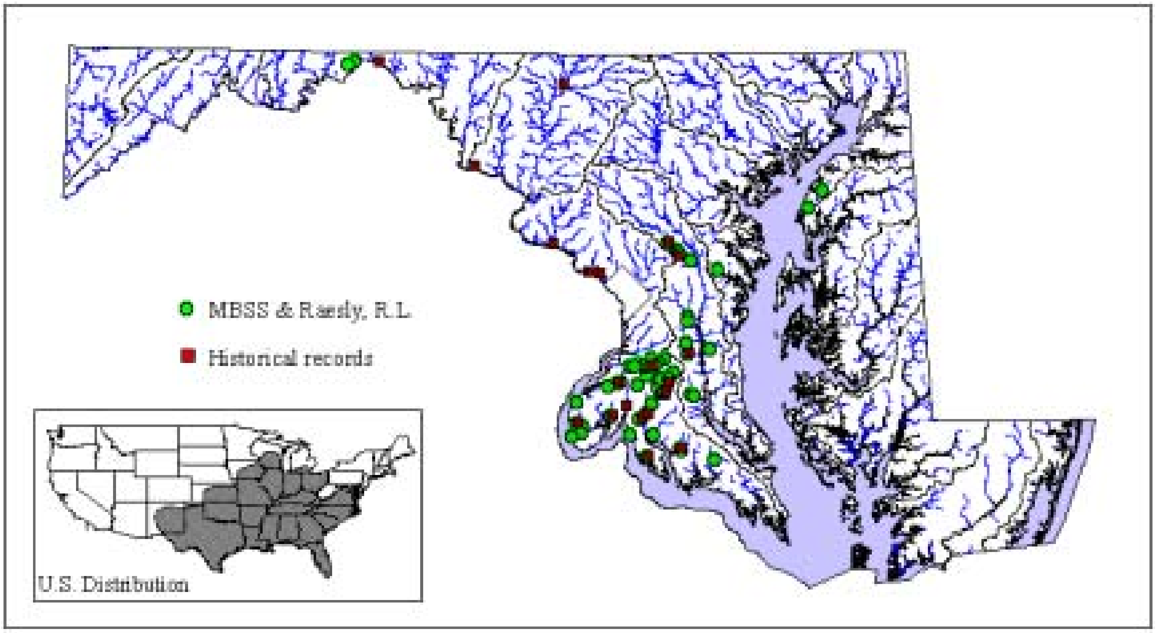


Fig. A-55. Records for warmouth in Maryland.

Status and Abundance: Although considered globally secure, warmouth is currently a species on the "Watch List" in Maryland. This species is also a GCN species in Pennsylvania. Based on quantitative MBSS electrofishing data, there are currently an estimated 34,429 ± 18,597 warmouth in Maryland.

Key Habitats: Warmouth is associated with Blackwater and Coastal Plain streams (MDNR 2005). The stronghold watersheds for warmouth include Mattawoman Creek, Lower Chester River, Zekiah Swamp, Nanjemoy Creek, Breton Bay, Potomac River Lower Tidal, and Gilbert Swamp. These watersheds are essential for the conservation of warmouth in Maryland.

Species Associations: A total of 52 different fish species were present at sites where warmouth was collected. The five species that most often co-occurred with warmouth included: eastern mudminnow, American eel, pumpkinseed, bluegill (non-native), and creek chubsucker.

Stressors: Three of the stronghold watersheds for warmouth experienced substantial increase in urban land use from 1973 to 2000 (Table A-1). Impervious surfaces associated with urban landscapes are known to negatively affect stream health, and will likely reduce warmouth populations if left unmitigated. The other stronghold watersheds experienced a slight increase in urban land use during the same period. Land use change, if continued, could ultimately degrade critical habitats and reduce populations in these watersheds. A list of other stressors in watersheds with warmouth populations is shown in Appendix D. The ranges of chemical and physical conditions at sites occupied by warmouth, as well as landscape attributes of the watershed upstream of these sites are shown in Figure A-56. These data are summarized from random MBSS sites sampled between 1995-2003.

Conservation Actions:

The maintenance of viable populations of warmouth in Maryland requires the protection of critical habitats. Restoration of riparian buffers and the reduction (or full elimination) of stream channelization will serve to protect these habitats. Farming practices that aim to reduce nutrient and pesticide run-off will protect warmouth habitats. Full mitigation of urbanization and management designed to limit impervious surface will benefit populations of warmouth in watersheds undergoing urbanization. Additionally, management that aims to preserve or enhance the connectivity of warmouth habitats will also benefit this species. A list of other conservation actions is shown in Table 9-10 of this volume.

Monitoring, Planning and Coordination Needs:

The Maryland Biological Stream Survey 1995-2004 identified warmouth populations in 17 8-digit watersheds in the state. Sample site density and MBSS methodology were sufficient to describe the statewide distribution and identify stronghold watersheds of this species. However, additional random sampling will improve our understanding of warmouth distribution and abundance, and track changes over time. Because local government decisions have a large impact on how and where development occurs, coordination and participation in conservation planning between DNR and counties will be necessary for the future conservation of warmouth populations and critical habitats.

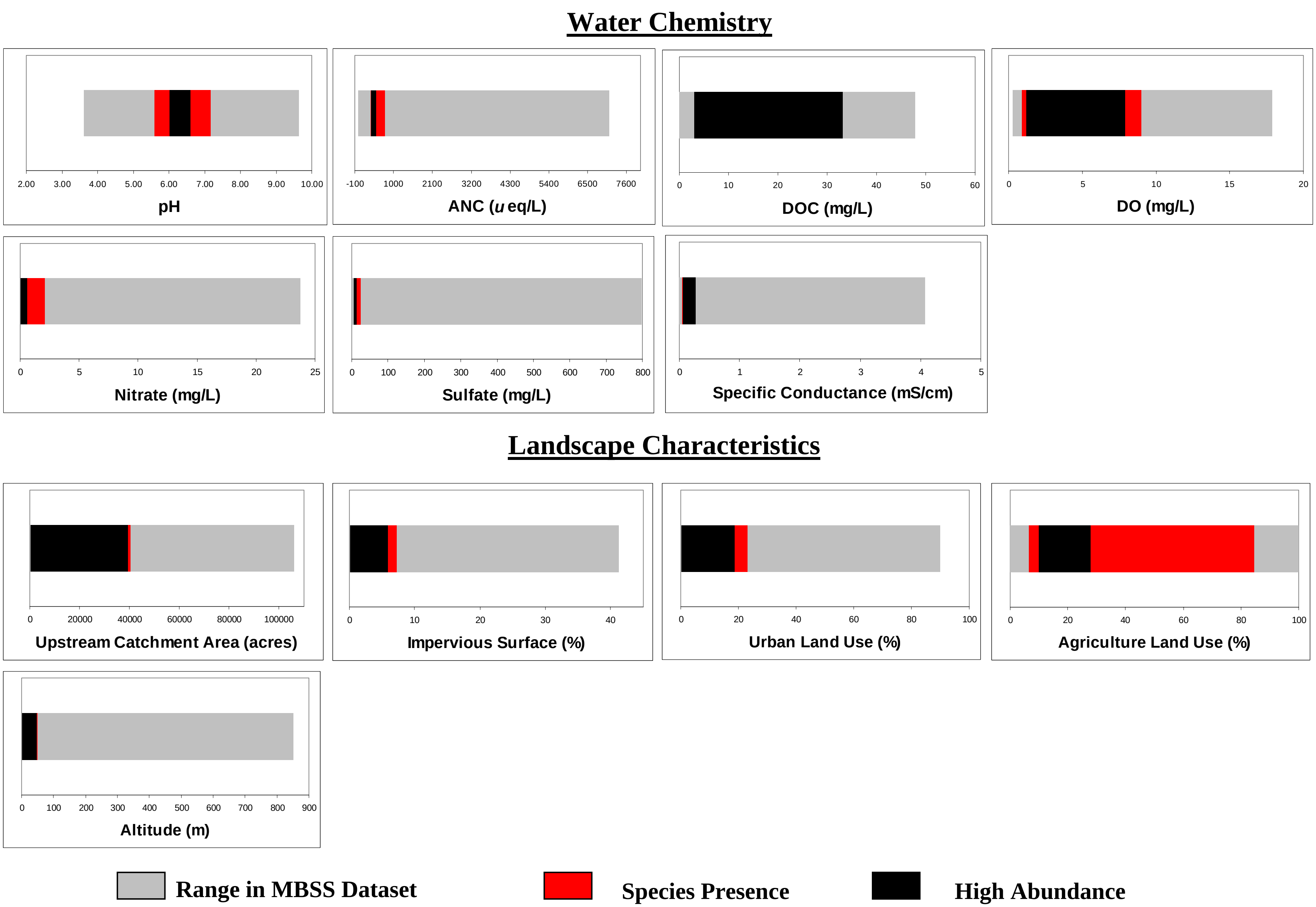


Fig. A-56: Warmouth range and high (above average) abundance thresholds for select variables. Water temperature, DO, and stream discharge were measured from June 1 to September 30. All water chemistry data were collected from March 1 to April 30.

Physical Habitat

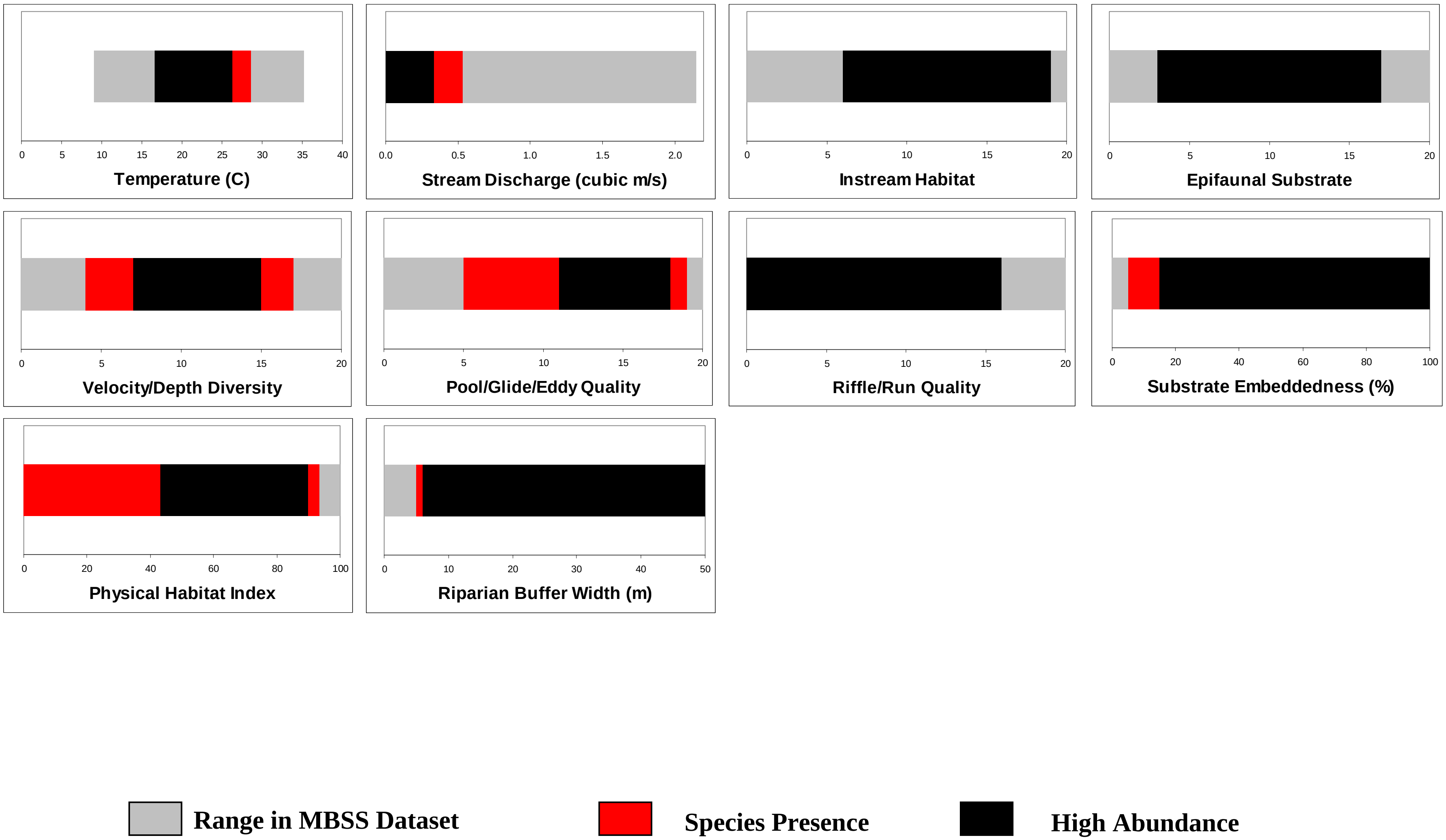


Fig. A-56: continued.

Literature Cited:

Angermeier, P.L. 1985. Spatio-temporal patterns of foraging success for fishes in an Illinois stream. American Midland Naturalist 114:342-359.

Bailey, J.E. 1952. Life history and ecology of the sculpin *Cottus bairdi punctulatus* in southwestern Montana. Copeia 1952:243-255.

Becker, G.C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison.

Breder, C.M., and D.R. Crawford. 1922. The food of certain minnows. Zoologica (New York) 2:287-327.

Breder, C.M., and A.C. Redmond. 1929. The bluespotted sunfish: a contribution to the life history and habits of *Enneacanthus* with notes on other Lepominae. Zoologica (New York) 9:379-401.

Breder, C.M. 1936. The reproductive habits of North American sunfishes (family Centrarchidae). Zoologica (New York) 21:1-48.

Breder, C.M., and D.E. Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, New York.

Carlander, K.D. 1969. Handbook of freshwater fishery biology, volume 1. Iowa State University Press, Ames.

Carlander, K.D. 1977. Handbook of freshwater fishery biology, volume 2. Iowa State University Press, Ames.

Clemens, W.A., J.R. Dymond, N.K. Bigelow, F.B. Adamstone, and W.J.K. Harkness. 1923. The food of Lake Nipigon Fishes. University of Toronto Studies 22.

Clemmons, M.M., and D.G. Lindquist. 1983. Reproductive biology of the swamp darter in Lake Waccamaw, North Carolina. Page 12 *in* Abstracts of the 63rd Annual Meeting of the American Society of Ichthyologists and Herpetologists.

Cohen, A.B. 1977. Life history of the banded sunfish (*Enneacanthus obesus*) in Green Falls Reservoir, Connecticut. Master's Thesis. University of Connecticut, Storrs.

COMAR (Code of Maryland) 08.03.08. 2003. Maryland Department of Environment. Baltimore, Maryland.

Davis, R.M. 1972. Age, growth, and fecundity of the rosyside dace, *Clinostomus funduloides* Girard. Chesapeake Science 13:63-66.

Dineen, C.F. 1951. A comparative study of the food habits of *Cottus bairdii* and associated species of Salmonidae. American Midland Naturalist 46:640-645.

Elser, H.J. 1961. These are the champs: record Maryland fishes. Maryland Conservationist 38(2):15-17.

Etnier, D.A. and W.C. Starnes. 1993. The fishes of Tennessee. The University of Tennessee Press, Knoxville.

Fahy, W.E. 1954. The life history of the northern greenside darter, *Etheostoma blennioides blennioides* Rafinesque. Journal of the Elisha Mitchell Scientific Society 70:139-205.

Fava, J.A., Jr., and C. Tsai. 1976. The life history of the pearl dace, *Semotilus margarita* in Maryland. Chesapeake Science 15:159-162.

Flemer, D.A., and W.S. Woolcott. 1966. Food habits and distribution of the fishes of Tuchahoe Creek, Virginia, with special emphasis on the bluegill, *Lepomis m. macrochirus* Rafinesque. Chesapeake Science 7:75-89.

Forbes, S.A. 1903. On the food of young fishes, 2nd edition. Reprint and emendment of Bulletin of the Illinois State Laboratory of Natural History 1(2):71-89.

Gatz, A.J. 1979. Ecological morphology of freshwater stream fishes. Tulane Studies in Zoology and Botany 21:91-124.

George, A. 2005. Personal communication from A. George, St. Louis University, St. Louis, MO.

Gillen, A.L., and T. Hart. 1980. Feeding interrelationships between the sand shiner and the striped shiner. Ohio Journal of Science 80:71-76.

Greeley, J.R. 1929. Fishes of the Erie-Niagara watershed. Pages 150-179 *in* A biological survey of the Erie-Niagara system. Supplemental to 18th Annual Report of the New York State Conservation Department, Albany.

Hankinson, T.L. 1919. Notes on life-histories of Illinois fishes. Transactions of the Illinois State Academy of Science 12:132-150.

Harrington, R.W. 1947a. The early life history of the bridled shiner, *Notropis bifrenatus* (Cope). Copeia 1947:97-102.

Harrington, R.W. 1947b. The breeding behavior of the bridled shiner, *Notropis bifrenatus* (Cope). Copeia 1947:186-192.

Harrington, R.W. 1948a. The life cycle of the bridled shiner, *Notropis bifrenatus* (Cope). American Midland Naturalist 39:83-92.

Harrington, R.W. 1948b. The food of the bridled shiner, *Notropis bifrenatus* (Cope). American Midland Naturalist 40:353-361.

Harrington, R.W. 1951. Notes on spawning in an aquarium by the bridled shiner, *Notropis bifrenatus*, with counts of the eggs deposited. Copeia 1951:85-86.

Hastings, R.W. 1979. Fish of the Pine Barrens. Pages 489-504 *in* R.T.T. Forman, editor. Pine Barrens: ecosystem and landscape. Academic Press, New York.

Hendricks, M.L., J.R. Stauffer, Jr., C.H. Hocutt, and C.R. Gilbert. 1979. A preliminary checklist of the fishes of the Youghiogheny River. Chicago Academy of Sciences, Natural History Miscellanea 203:1-15.

Hendricks, M.L. 1980. The distribution of the fishes of the Youghiogheny River. M.S. Thesis. Appalachian Environmental Laboratory, University of Maryland. Frostburg, Maryland.

Hildebrand, S.F., and W.C. Schroeder. 1928. Fishes of Chesapeake Bay. U.S. Bureau of Fisheries Bulletin 43. (Reprinted 1972. Tropical Fish Hobbyist Publications, Neptune City, New Jersey.)

Holbrook, W.P. 1975. Fecundity and sex ratio in the least brook lamprey, *Lampetra aepyptera* (Abbott) in Lynn Creek, Wayne County, West Virginia. Proceedings of the West Virginia Academy of Science 57:150-153.

House, R., and L. Wells. 1973. Age, growth, spawning season, and fecundity of the troutperch (*Percopsis omiscomaycus*) in southeastern Lake Michigan. Journal of the Fisheries Research Board of Canada 30:1221-1225.

Hoyt, R.D. 1970. Food habits of the silverjaw minnow, *Ericymba buccata* Cope, in an intermittent stream in Kentucky. American Midland Naturalist 84:226-236.

Hoyt, R.D. 1971a. The reproductive biology of the silverjaw minnow, *Ericymba buccata* Cope, in Kentucky. Transactions of the American Fisheries Society 100:510-519.

Hoyt, R.D. 1971b. Age and growth of the silverjaw minnow, *Ericymba buccata* Cope, in Kentucky. American Midland Naturalist 86:257-275.

Hubbs, C., and K. Strawn. 1963. Differences in the developmental temperature tolerance of central Texas and more northern stocks of *Percina caprodes* (Percidae: Osteichthyes). Southwestern Naturalist 8:43-45.

Jenkins, R.E., and N.M. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Jenkins, R.E., and T. Zorach. 1970. Zoogeography and characters of the American cyprinid fish *Notropis bifrenatus*. Chesapeake Science 11:174-182.

Karr, J.R. 1963. Age, growth, and food habits of Johnny, slenderhead and blacksided darters of Boone County, Iowa. Proceedings of the Iowa Academy of Science 70:228-236.

Katula, R.S. 1986. Greenside gourmet. American Currents:6.

Kinziger, A.P., and R.L. Raesly. 2001. A narrow hybrid zone between two *Cottus* species in Wills Creek, Potomac drainage. Journal of Heredity 92:309-314.

Kline, M.J. and R.P. Morgan II. 2000. Current distribution, abundance, and habitat preferences of the stonecat (*Noturus flavus*) in Maryland. Maryland Department of Natural Resources, Monitoring and Non-Tidal Division, Annapolis, Maryland.

Knapp, L.W. 1976. Redescription, relationships, and status of the Maryland darter, *Etheostoma sellare* (Radcliffe and Welsh), an endangered species. Proceedings of the Biological Society of Washington 89:99-118.

Koster, W.J. 1936. The life-history and ecology of the sculpins (Cottidae) of central New york. Abstract of Doctoral dissertation. Cornell University, Ithaca, New York.

Koster, W.J. 1937. The food of sculpins (Cottidae) in central New York. Transactions of the American Fisheries Society 66:374-382.

Koster, W.J. 1939. Some phases of the life history and relationships of the cyprinid, *Clinostomus elongatus* (Kirtland). Copeia 1939:201-208.

Lachner, E.A., E.F. Westlake, and P.S. Handwerk. 1950. Studies on the biology of some percid fishes from western Pennsylvania. American Midland Naturalist 43:92-111.

Langlois, T.H. 1929. Breeding habits of the northern dace. Ecology 10:161-163.

Larimore, R.W. 1957. Ecological life history of the warmouth (Centrarchidae). Illinois Natural History Survey Bulletin 27:1-83.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh.

Lee, D.S., A. Norden, C.R. Gilbert, and R. Franz. 1976. A list of the freshwater fishes of Maryland and Delaware. Chesapeake Science 17:205-211.

Lee, D.S., S.P. Platania, C.R. Gilbert, R. Franz, and A. Norden. 1981. A revised list of the freshwater fishes of Maryland and Delaware. Southeastern Fishes Council Proceedings 3:2-10.

Loos, J.J., and L.A. Fuiman. 1978. Subordinate taxa of the genus *Notropis*: a preliminary comparative survey of their developmental traits. Pages 1-50 *in* L.L. Olmsted, editor. Proceedings of the first symposium on freshwater larval fish. Duke Power Company, Huntersville, North Carolina.

Loos, J.J., and W.S. Woolcott. 1969. Hybridization and behavior in two species of *Percina* (Percidae). Copeia 1969:374-385.

Lotrich, V.A. 1973. Growth, production, and community composition of fishes inhabiting a first-, second-, and third-order stream of eastern Kentucky. Ecological Monographs 43:377-397.

Lucas, M.C., E. Baras, T.J. Thom, A. Duncan, and O. Slavik. 2001. Migration of freshwater fishes. Blackwell Science Ltd, United Kingdom.

Lutherbie, G.W. 1979. Reproduction and age and growth in Wisconsin darters. Museum of Natural History, Reports on the Fauna and Flora of Wisconsin 15, University of Wisconsin-Stevens Point.

Magnuson, J.J., and L.L. Smith. 1963. Some phases of the life history of the trout-perch. Ecology 44:83-95.

Mansueti, R.J. 1957. Rare longnose and sturgeon sucker found in Maryland. Maryland Tidewater News 13(7):2.

Mansueti, R.J. 1964. Eggs, larvae, and young of the hickory shad, *Alosa mediocris*, with comments on its ecology in the estuary. Chesapeake Science 3:173-205.

Mansueti, R.J., and H.J. Elser. 1953. Ecology, age and growth of the mud sunfish, *Acantharchus pomotis*, in Maryland. Copeia 1953:117-119.

Marshall, N.B. 1939. Annulus formation in scales of the common shiner, *Notropis cornutus chrysocephalus* (Rafinesque). Copeia 1939:148-154.

Matheney, M.P.IV, and C.F. Rabeni. 1995. Patterns of movement and habitat use by Northern hog suckers in an Ozark stream. Transactions of the American Fisheries Society 124:886-897.

McCormick, F.H., and N. Aspinwall. 1983. Habitat selection in three species of darters. Pages 117-120 *in* D.L.G. Noakes, D.G. Lindquist, G.S. Helfman, and J.A. Ward, editors. Predators and prey in fishes. Dr. W. Junk, The Hague, Netherlands.

Mettee, M.F., P.E. O'Neil, and J.M. Pierson. 1996. Fishes of Alabama and the Mobile basin. Oxmoor House, Birmingham, Alabama.

Morgan, R.P., II, D.J. Wiley, M.J. Kline, J.D. Holt, and S.S. Stranko. 2004. *in press*. Managing brook trout populations in an urban environment. Proceedings of Wild Trout Symposium.

Mullan, J.W., R.L. Applegate, and W.C. Rainwater. 1968. Food of the logperch (*Percina caprodes*), and brook silverside (*Labidesthes sicculus*). Transactions of the American Fisheries Society 97:300-305.

Musick, J.A. 1972. Fishes of Chesapeake Bay and the adjacent Coastal Plain. Pages 175-212 *in* M.L. Wass, editor. A check list of the biota of lower Chesapeake Bay. Virginia Institute of Marine Science Special Scientific Report 65.

Muth, S.E., and D.C. Tarter. 1975. Reproductive biology of the trout perch, *Percopsis omiscomaycus* (Walbaum), in Beech Fork of Twelvepole Creek, Wayne County, West Virginia. American Midland Naturalist 93:434-439.

Nagel, J.W. 1991. Is the decline of brook trout in the southern Appalachians resulting from competitive exclusion and/or extinction due to habitat fragmentation? Journal of the Tennessee Academy of Science 4:141-143.

Near, T.J. and M.F. Benard. 2004. Rapid allopatric speciation in logperch darters (Percidae: *Percina*). Evolution 58 (12): 2798-2808.

Norman, M.D. 1973. Southeastern Virginia impoundment survey. Virginia Commission of Game and Inland Fisheries, Federal Aid in Sport Fish Restoration, Project F-24, April 1971-July 1972. Progress Report, Richmond.

Occhiogrosso, T., and S. Goodbred. 1981. The bluespotted sunfish. New York State Conservationist 36(1):41.

Page, L.M. 1983. Handbook of darters. Tropical Fish Hobbyist Publications, Neptune City, New Jersey.

Paine, M.D., J.J.Dodson, and G. Power. 1982. Habitat and food resource partitioning among four species of darters (Percidae: *Etheostoma*) in a southern Ontario stream. Canadian Journal of Zoology 60:1635-1641.

Parrish, J.D., D.C. Heins, and J.A. Baker. 1991. Reproductive season, clutch parameters and oocyte size in the Johnny darter *Etheostoma nigrum* from southwestern Mississippi. American Midland Naturalist 125:180-186.

Quinn, J.R. 1988. The best and the brightest: the cosmopolitan *Chaetodon*. Tropical

Fish Hobbyist 36:59-68.

Radcliffe, L. and W.W. Welsh. 1913. Description of a new darter from Maryland. Bull. U.S. Bur. Fish. 32:29-32.

Raesly, R.L. 1991. Current population status of the endangered Maryland darter, *Etheostoma sellare*, in Deer Creek, Maryland. Abstract from the 71st Meeting of the American Society of Ichthyologists and Herpetologists. American Museum of Natural History. New York, New York.

Raesly, R.L. 1998. Status and distribution of the trout perch, *Percopsis omiscomaycus*, in Maryland. Final Report submitted to Maryland Department of Natrual Resources, Maryland Natural Heritage Program, Annapolis, Maryland.

Raesly, R.L. and Kazyak, P.F. 2004. Maryland Rare Fishes Survey 2002-2004. Final Report submitted to Maryland Department of Natural Resources, Maryland Natural Heritage Program, Annapolis, Maryland.

Raesly, R.L., P.F. Kazyak, and R. Hilderbrand. 2004. Inventory and biological monitoring of fishes in National parks of the National Capital Region. Final report submitted to National Park Service, Center for Urban Ecology, Washington, D.C.

Raesly, R.L., R.E. Gregg, and J.H. Howard. 2005. A new species of sculpin (Cottidae: *Cottus*) from the Potomac River drainage of Maryland, Pennsylvania, Virginia, and West Virginia. *In review*. Copeia.

Raney, E.C., and E.A. Lachner. 1946. Age, growth, and habits of the hog sucker, *Hypentelium nigricans* (Lesueur), in New York. American Midland Naturalist 36:76-86.

Reagan, N.L., and J.L. West. 1984. Life history of the mottled sculpin in a western North Carolina stream. Association of Southeastern Biologists Bulletin 31:78.

Reighard, J. 1913. The breeding habits of the logperch (*Percina caprodes*). Fifteenth Report of the Michigan Academy of Science 15:104-105.

Roberts, N.J. and H.E. Winn. 1962. Utilization of the senses in feeding behavior of the Johnny darter, *Etheostoma nigrum*. Copeia 1962:567-570.

Rohde, F.C., and R.G. Arndt. 1981. Life history of a Coastal Plain population of the mottled sculpin, *Cottus bairdi* (Osteichthyes: Cottidae). Brimleyana 7:69-94.

Rohde, F.C., R.G. Arndt, and J.C.S. Wang. 1976. Life history of the freshwater lampreys, *Okkelbergia aepyptera* and *Lampetra lamottenii* (Pisces: Petromyzonidae), on the Delmarva Peninsula (East Coast, United States). Bulletin of the Southern California Academy of Sciences 75:99-111.

Roth, N.E., Southerland, M.T., J.C. Chaillou, J.H. Volstad, S.B. Weisberg, H.T. Wilson, D.G. Heimbuch, and J.C. Seibel. 1997. Maryland Biological Stream Survey: Ecological status of non-tidal streams in six basins sampled in 1995. Maryland Department of Natural Resources, Annapolis, Maryland.

Schmidt, R.E., and W.R. Whitworth. 1979. Distribution and habitat of the swamp darter (*Etheostoma fusiforme*) in southern New England. American Midland Naturalist 102:408-413.

Schwartz, F.J. 1961. Food, age, growth, and morphology of the blackbanded sunfish, *Enneacanthus c. chaetodon*, in Smithville Pond, Maryland. Chesapeake Science 2:82-88.

Schwartz, F.J. 1963. The freshwater minnows of Maryland. Maryland Conservationist XL:19-29.

Schwartz, F.J. 1964. Several Maryland fishes close to extinction. Maryland Conservationist XLI:8-12.

Schwartz, F.J. 1965. The distribution and probable postglacial dispersal of the percid fish, *Etheostoma b. blennioides*, in the Potomac River. Copeia 1965:285-290.

Seagle, H.H., and J.W. Nagel. 1982. Life cycle and fecundity of the American brook lamprey, *Lampetra appendix*, in Tennessee. Copeia 1982:362-366.

Seversmith, H.F. 1953. Distribution, morphology, and life history of *Lampetra aepyptera*, a brook lamprey, in Maryland. Copeia 1953:225-232.

Stasiak, R.H. 1978. Food, age and growth of the pearl dace, *Semotilus margarita*, in Nebraska. American Midland Naturalist 100:463-466.

Sternberg, J.G. 1986. Spawning the blackbanded sunfish. American Currents (January):6-7.

Stranko, S.A., M.K. Hurd and R.J. Klauda. 2005. (In Press). Applying a large, statewide data base to the assessment, stressor diagnosis, and restoration of stream fish communities. Environmental Monitoring and Assessment.

Swift, C.C., R.W. Yerger, and P.R. Parrish. 1977. Distribution and natural history of the fresh and brackish water fishes of the Ocklockonee River, Florida and Georgia. Bulletin of Tall Timbers Research Station 20.

Thomas, D.L. 1970. An ecological study of four darters of the genus *Percina* (Percidae) in the Kaskaskia River, Illinois. Illinois Natural History Survey Biological Notes 70.

Trautman, M.B. 1981. The fishes of Ohio with illustrated keys, revised edition. Ohio State University Press, Columbus.

Turner, C.L. 1921. Food of the common Ohio darters. Ohio Journal of Science 22:41-62.

Uhler, P.R., and O. Lugger. 1876. List of the fishes of Maryland. Rept. Comm. Fisheries, Maryland 1876:67-176.

Wallace, D.C. 1971. The age and growth of the silverjaw minnow, *Ericymba buccata* Cope. American Midland Naturalist 86:116-127.

Wallace, D.C. 1973. Reproduction of the silverjaw minnow, *Ericymba buccata* Cope. Transactions of the American Fisheries Society 102:786-793.

Wallace, D.C. 1976. Feeding behavior and developmental, seasonal, and diel changes in the food of the silverjaw minnow, *Ericymba buccata* Cope. American Midland Naturalist 95:361-376.

Walsh, S.J., and B.M. Burr. 1981. Distribution, morphology and life history of the least brook lamprey, *Lampetra aepyptera* (Pisces: Petromyzonidae), in Kentucky. Brimleyana 6:83-100.

Walsh, S.J., and B.M. Burr. 1985. The biology of the stonecat, *Noturus flavus* (Siluriformes: Ictaluridae), in central Illinois and Missouri streams, and comparisons with Great Lakes populations and congeners. Ohio Journal of Science 85:85-96.

Wang, J.C.S., and R.J. Kernehan. 1979. Fishes of the Delaware estuaries: a guide to the early life histories. E A Communications, Ecological Analysts, Towson, Maryland.

Werner, R.G. 1972. Bluespotted sunfish, *Enneacanthus gloriosus*, in the Lake Ontario drainage, New York. Copeia 1972:878-879.

Winn, H.E. 1958a. Observations on the reproductive habits of darters (Pisces: Percidae). American Midland Naturalist 59:190-212.

Winn, H.E. 1958b. Comparative reproductive behavior and ecology of fourteen species of darters (Pisces-Percidae). Ecological Monographs 28:155-191.

Winn, H.E., and A. R. Picciolo. 1960. Communal spawning of the glassy darter *Etheostoma vitreum* (Cope). Copeia 1960:186-192.

Wolfe, G.W., B.H. Bauer, and B.A. Branson. 1978. Age and growth, length-weight relationships, and condition factors of the greenside darter from Silver Creek, Kentucky. Transactions of the Kentucky Academy of Science 39:131-134.

Wujtewicz, D. 1982. The feasibility of utilizing minnows as forage in farm ponds, 4: a life history of the black-banded sunfish *Enneacanthus chaetodon*, in Hudson Pond, Delaware. Delaware State College, Natural Resources Report 3, Dover.

Table A-1. Land use change in GCN fish species stronghold watersheds from 1973 to 2000. Species highlighted in bold are stronghold species. Land use data provided by the Maryland Department of Planning.

Stronghold Watershed	**1973 (%)**			**2000 (%)**			**% Increase of Urban Land Use**	**GCN Fish Species**
	Agriculture	**Forest**	**Urban**	**Agriculture**	**Forest**	**Urban**		
Anacostia River	11.8	32.4	55.0	2.4	16.6	78.6	23.6	American brook lamprey Bluespotted sunfish Least brook lamprey Northern hogsucker Rosyside dace **Silverjaw minnow**
Antietam Creek	62.6	27.9	9.4	48.5	28.6	22.7	13.3	Brook trout **Checkered sculpin** Comely shiner Greenside darter Northern hogsucker **Pearl dace** Rosyside dace
Atkisson Reservoir	52.7	33.5	13.6	39.5	26.0	34.1	20.5	**Comely shiner** Least brook lamprey **Northern hogsucker** **Rosyside dace**
Big Elk Creek	51.8	41.8	6.2	47.6	39.5	12.5	6.3	Least brook lamprey **Northern hogsucker** Rosyside dace
Bohemia River	66.1	21.0	1.2	63.9	21.1	3.2	2.0	Bluespotted sunfish Least brook lamprey
Breton Bay	26.4	60.3	4.6	23.0	54.3	13.4	8.8	Comely shiner **Flier** Least brook lamprey **Warmouth**
Brighton Dam	62.1	33.0	2.9	49.4	33.5	15.1	12.2	Northern hogsucker Rosyside dace **Shield darter**
Broad Creek	60.8	36.2	2.7	54.6	33.8	11.2	8.5	Comely shiner **Logperch** Northern hogsucker Rosyside dace **Shield darter**
Bush River	19.6	42.1	14.6	16.0	37.9	20.6	6.0	Banded sunfish Northern hogsucker Rosyside dace
Bynum Run	43.8	33.8	22.6	23.0	23.5	53.2	30.6	**Northern hogsucker** Rosyside dace
Cabin John Creek	2.4	22.8	74.5	0.8	12.6	86.5	12.0	Greenside darter Northern hogsucker Rosyside dace **Silverjaw minnow**
Casselman River	27.0	69.3	2.2	25.4	65.8	7.3	5.1	Brook trout **Johnny darter** **Mottled sculpin** Northern hogsucker **Stonecat** **Striped shiner**

Catoctin Creek	64.9	32.8	2.3	53.7	34.9	11.4	9.1	Greenside darter Northern hogsucker Rosyside dace Silverjaw minnow
Chester River Lower	26.7	15.0	2.3	26.2	12.9	4.9	2.6	**Warmouth**
Chester River Middle	73.9	13.2	4.5	71.5	11.9	8.3	3.8	Bluespotted sunfish Least brook lamprey
Chester River Upper	63.6	33.3	1.3	63.7	30.9	3.3	2.0	**Bluespotted sunfish** **Least brook lamprey** **Mud sunfish** Swamp darter
Choptank River Upper	59.6	32.0	2.8	57.4	28.4	8.2	5.4	Bluespotted sunfish Comely shiner Least brook lamprey **Rosyside dace** Shield darter Swamp darter
Conococheague Creek	72.2	17.8	8.9	54.0	19.5	24.9	16.0	Greenside darter **Pearl dace**
Conowingo Dam Susquehanna River	33.3	49.3	3.4	30.0	35.8	11.7	8.3	**Logperch** **Northern hogsucker** Rosyside dace **Shield darter**
Corsica River	62.9	28.6	2.7	60.4	26.8	6.9	4.2	Least brook lamprey **Rosyside dace**
Deep Creek Lake	23.1	61.3	5.5	19.8	48.5	19.6	14.1	Brook trout **Johnny darter**
Deer Creek	62.0	34.1	4.0	55.5	31.8	12.4	8.4	Brook trout **Logperch** Northern hogsucker **Rosyside dace** **Shield darter**
Dividing Creek	19.7	79.6	0.0	20.1	77.5	1.7	1.7	Banded sunfish **Bluespotted sunfish** **Mud sunfish** **Swamp darter**
Double Pipe Creek	78.5	17.0	4.4	68.9	19.3	11.7	7.3	Comely shiner **Greenside darter** Northern hogsucker Rosyside dace **Silverjaw minnow**
Elk River Upper	23.4	51.2	12.4	15.7	46.1	25.2	12.8	Bluespotted sunfish Least brook lamprey Northern hogsucker Rosyside dace
Fifteen Mile Creek	5.7	94.4	0.0	5.4	92.6	2.0	2.0	**Greenside darter** Northern hogsucker
Furnace Bay	46.8	43.8	5.6	40.3	41.4	14.3	8.7	Northern hogsucker **Rosyside dace**
Gilbert Swamp	38.3	59.4	1.4	33.2	52.5	13.1	11.7	Least brook lamprey Rosyside dace **Warmouth**
Gunpowder River	4.5	25.8	19.5	2.6	23.8	22.6	3.1	
Isle of Wight Bay	35.5	34.3	8.3	30.2	29.0	19.3	11.0	**Bluespotted sunfish**
Little Conococheague River	58.2	40.1	1.5	48.0	40.9	10.9	9.4	Greenside darter Northern hogsucker Rosyside dace

Little Gunpowder Falls	52.0	35.2	12.3	42.5	32.7	24.0	11.7	Brook trout Northern hogsucker Rosyside dace **Shield darter**
Little Patuxent River	26.0	45.3	28.3	12.7	37.0	49.8	21.5	**American brook lamprey** Bluespotted sunfish **Glassy darter** Least brook lamprey Northern hogsucker Rosyside dace Shield darter
Little Youghiogheny River	45.1	44.4	7.6	41.1	41.8	16.3	8.7	Brook trout **Mottled sculpin**
Lower Winters Run	28.8	50.4	18.5	16.2	40.2	40.8	22.3	**Comely shiner** **Northern hogsucker** Rosyside dace
Manokin River	24.9	37.6	1.4	23.5	36.5	4.6	3.2	Banded sunfish **Bluespotted sunfish** **Mud sunfish** Swamp darter
Marsh Run	74.3	15.6	10.2	56.6	19.5	23.8	13.6	Greenside darter Northern hogsucker **Pearl dace**
Marshyhope Creek	53.6	39.4	2.2	52.9	36.6	5.7	3.5	**Banded sunfish** Bluespotted sunfish **Glassy darter** Least brook lamprey **Swamp darter**
Mattawoman Creek	15.7	68.4	12.1	12.0	58.1	25.7	13.6	Bluespotted sunfish Least brook lamprey Rosyside dace **Warmouth**
Middle Patuxent River	55.2	37.5	7.2	36.3	28.5	35.0	27.8	Northern hogsucker **Rosyside dace** **Shield darter**
Monocacy River Lower	64.7	28.5	6.5	46.7	30.3	22.8	16.3	**Checkered sculpin** Comely shiner Greenside darter **Northern hogsucker** Pearl dace Rosyside dace **Silverjaw minnow**
Monocacy River Upper	60.2	36.6	3.3	50.7	39.7	9.5	6.2	**Brook trout** Comely shiner **Greenside darter** Northern hogsucker **Pearl dace** Rosyside dace **Silverjaw minnow**
Nanjemoy Creek	15.6	71.9	3.2	14.7	69.4	6.7	3.5	Bluespotted sunfish **Ironcolor shiner** Least brook lamprey Rosyside dace **Warmouth**
Nanticoke River	31.8	38.5	1.5	31.3	36.8	4.6	3.1	Bluespotted sunfish Least brook lamprey Mud sunfish Swamp darter

Nassawango Creek	26.3	72.8	0.4	25.1	70.8	3.6	3.2	**Banded sunfish** **Bluespotted sunfish** Least brook lamprey Mud sunfish **Swamp darter**
Northeast River	39.0	43.5	8.1	33.3	39.6	17.6	9.5	**Logperch** Northern hogsucker **Rosyside dace**
Octoraro Creek	62.0	33.6	4.4	50.6	30.8	18.4	14.0	**Logperch** Northern hogsucker Rosyside dace
Patapsco River Lower North Branch	17.3	51.1	30.0	12.2	38.6	47.0	17.0	Least brook lamprey Northern hogsucker Rosyside dace **Shield darter**
Patuxent River Lower	24.7	53.6	6.0	20.4	44.4	19.3	13.3	American brook lamprey Bluespotted sunfish Least brook lamprey Rosyside dace Warmouth
Patuxent River Middle	42.0	48.2	3.5	36.9	43.2	13.9	10.4	**American brook lamprey** Bluespotted sunfish Least brook lamprey Rosyside dace Warmouth
Patuxent River Upper	25.9	52.3	21.4	18.1	44.4	35.6	14.2	**American brook lamprey** Bluespotted sunfish **Glassy darter** Least brook lamprey Rosyside dace Shield darter Warmouth
Piscataway Creek	18.1	55.8	23.6	14.2	43.0	39.5	15.9	**American brook lamprey** **Comely shiner** Least brook lamprey Northern hogsucker Rosyside dace
Pocomoke River Lower	35.1	57.9	3.0	33.7	57.4	4.6	1.6	**Banded sunfish** Bluespotted sunfish Least brook lamprey **Mud sunfish** **Swamp darter**
Pocomoke River Upper	44.2	55.2	0.7	43.6	52.3	4.0	3.3	**Banded sunfish** **Bluespotted sunfish** **Glassy darter** Least brook lamprey Mud sunfish Shield darter **Swamp darter**
Pocomoke Sound	20.7	32.7	0.3	19.4	31.3	3.6	3.3	Banded sunfish
Port Tobacco River	21.6	61.7	9.4	19.0	52.6	20.6	11.2	Bluespotted sunfish **Flier** Least brook lamprey Rosyside dace Warmouth
Potomac River Frederick County	56.0	34.3	4.3	42.2	36.8	15.9	11.6	Greenside darter Northern hogsucker Rosyside dace Silverjaw minnow

Potomac River Lower North Branch	14.0	75.8	8.7	11.4	73.8	13.6	4.9	Brook trout Greenside darter Northern hogsucker Rosyside dace
Potomac River Lower Tidal	7.6	12.3	1.3	7.1	11.6	2.7	1.4	**Flier** Rosyside dace **Warmouth**
Potomac River Middle Tidal	3.6	35.8	2.9	3.2	34.1	5.1	2.2	Bluespotted sunfish **Least brook lamprey** Rosyside dace Warmouth
Potomac River Montgomery County	40.6	32.2	20.6	25.7	29.0	37.3	16.7	Greenside darter Northern hogsucker Rosyside dace **Silverjaw minnow**
Potomac River Upper North Branch	17.6	75.3	6.0	15.2	74.1	9.6	3.6	**Brook trout**
Potomac River Upper Tidal	7.0	39.2	29.8	4.4	26.6	41.9	12.1	Least brook lamprey Rosyside dace
Potomac River Washington County	42.0	47.7	2.6	33.8	46.5	12.5	9.9	Greenside darter **Pearl dace**
Prettyboy Reservoir	54.2	37.6	5.0	45.8	36.8	14.1	9.1	**Brook trout** Northern hogsucker Rosyside dace Silverjaw minnow
Rocky Gorge Dam	48.3	36.5	12.0	27.9	38.0	31.0	19.0	Northern hogsucker Rosyside dace **Shield darter**
Savage River	14.9	82.8	1.2	14.4	81.4	3.4	2.2	**Brook trout** Northern hogsucker Rosyside dace
Seneca Creek	57.5	32.2	9.7	34.4	32.6	32.0	22.3	Comely shiner Greenside darter Northern hogsucker Rosyside dace **Silverjaw minnow**
Sidling Hill Creek	20.0	80.1	0.0	17.6	79.0	3.2	3.2	**Comely shiner** **Greenside darter** Northern hogsucker Striped shiner
St. Clements Bay	37.2	48.7	3.1	34.6	45.7	8.5	5.4	**Least brook lamprey**
St. Mary's River	20.7	55.3	6.4	18.0	47.6	16.1	9.7	Bluespotted sunfish Comely shiner **Flier** **Ironcolor shiner** Least brook lamprey
Susquehanna River Lower	27.6	39.0	15.9	23.0	33.9	24.1	8.2	
Swan Creek	40.9	36.9	17.5	31.7	32.5	30.7	13.2	Least brook lamprey Northern hogsucker Rosyside dace
Town Creek	18.7	80.9	0.4	19.3	78.4	2.3	1.9	**Comely shiner** **Greenside darter** Northern hogsucker Rosyside dace Silverjaw minnow

Transquaking River	42.7	37.9	0.3	43.9	35.1	1.7	1.4	**Banded sunfish** Bluespotted sunfish Least brook lamprey Mud sunfish **Swamp darter**
Tuckahoe Creek	69.1	28.6	0.6	68.5	26.2	3.6	3.0	**Bluespotted sunfish** Comely shiner **Ironcolor shiner** Least brook lamprey Mud sunfish **Rosyside dace** **Shield darter** Swamp darter
Western Branch	33.1	48.9	17.4	15.0	39.3	42.5	25.1	**American brook lamprey** Banded sunfish Bluespotted sunfish **Glassy darter** Least brook lamprey Rosyside dace **Stripeback darter** Warmouth
Wicomico Creek	39.0	53.8	1.5	38.5	50.9	10.4	8.9	Bluespotted sunfish **Mud sunfish**
Wicomico River Head	43.8	46.0	9.8	35.1	38.7	25.3	15.5	Banded sunfish Bluespotted sunfish Least brook lamprey Swamp darter
Wicomico River Lower	34.1	38.0	10.0	28.0	32.2	21.5	11.5	Bluespotted sunfish Least brook lamprey Swamp darter
Wills Creek	11.7	74.5	13.7	9.0	73.4	17.5	3.8	**Brook trout** Greenside darter Northern hogsucker Rosyside dace
Wye River	63.5	23.6	1.1	59.4	21.6	6.8	5.7	**Least brook lamprey**
Youghiogheny River	29.4	68.7	1.1	25.6	65.8	7.5	6.4	**Brook trout** Greenside darter **Johnny darter** **Mottled sculpin** Northern hogsucker Rosyside dace **Striped shiner**
Zekiah Swamp	26.5	67.5	5.6	22.1	58.0	18.1	12.5	**Bluespotted sunfish** **Flier** **Ironcolor shiner** **Least brook lamprey** Rosyside dace Swamp darter **Warmouth**

Appendix B. Amphibian species of Greatest Conservation Need in Maryland

The Maryland Department of Natural Resources, Natural Heritage Program considers 18 of the 41 (44%) Maryland amphibian species to be in greatest conservation need (GCN) because they are at risk of extirpation or are declining precipitously. Six of these, including the eastern tiger salamander (*Ambystoma tigrinum tigrinum*), eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*), green salamander (*Aneides aeneus*), barking treefrog (*Hyla gratiosa*), eastern narrow-mouthed toad (*Gastrophryne carolinensis*), and mountain chorus frog (*Pseudacris brachyphona*) are state threatened or endangered. Table 1 lists these and Maryland's other 12 GCN species. This table also provides a priority value and rarity score for each species. The priority value for each species is based on the perceived level of conservation need, with higher scores indicating more urgent need for conservation. The rarity score is the percent of Maryland's 137, 8-digit watersheds where the species is currently thought to exist.

The species accounts that follow provide the life history, status, general distribution, habitat preferences, threats, conservation needs and future monitoring needs.
We hope that this information will be useful in developing effective conservation strategies for Maryland's GCN amphibians.

Life History
Amphibian species accounts are grouped by the preferred breeding habitats for species. There are three general types of habitats that Maryland amphibians utilize for breeding: ponds (lentic water), streams (lotic water), and terrestrial. A more complete description of these three disparate life history strategies precedes the species accounts for each group.

Status
The status is reported for those species that are listed in the Maryland Department of Natural Resources, Natural Heritage Program list of rare, threatened, and endangered plants and animals as last updated in December of 2003. The state rank is reported for those species that are on the Natural Heritage Program list without an official state status. For those GCN species not listed the status is simply reported as GCN.

Interpreting Distribution Maps
The distribution maps shown in this report include historic and current distribution information by county. Counties in green represent the current distribution of the species and counties with hatches represent the historic distribution. The distribution may only be shown as portions of a county where an amphibian is known only to occur in one of the physiographic regions in a county (Figure 1).

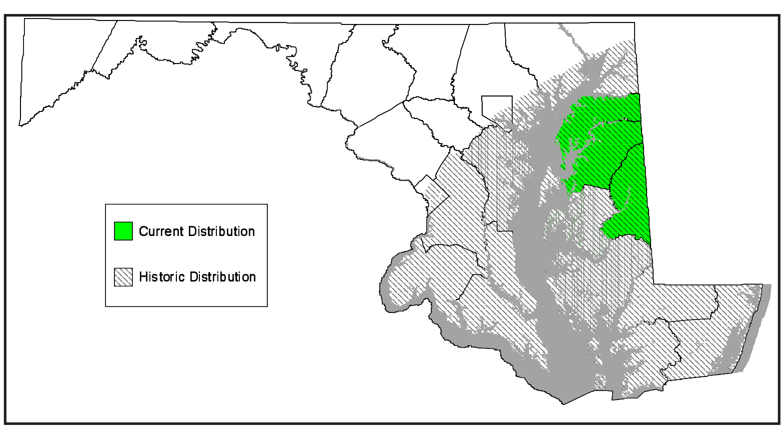


Figure 1. Hypothetical amphibian distribution map showing the current and historic range.

Table1. Maryland's GCN amphibians with their state listing status ranked by the priority ranking score.

Common Name	Scientific Name	Priority Ranking Score	Rarity Score
Eastern hellbender	*Cryptobranchus a. alleghenіensis*	200	0.7
Green salamander	*Aneides aeneus*	150	0.7
Common mudpuppy	*Necturus m. maculosus*	50	0.7
Barking treefrog	*Hyla gratiosa*	50	2.9
Eastern narrow-mouthed toad	*Gastrophryne carolinensis*	50	6.6
Eastern tiger salamander	*Ambystoma t. tigrinum*	25	4.3
Wehrle's salamander	*Plethodon wehrlei*	25	2.2
Eastern mud salamander	*Pseudotriton m. montanus*	25	15.9
Mountain chorus frog	*Pseudacris brachyphona*	25	2.9
Carpenter frog	*Rana virgatipes*	25	9.4
Jefferson salamander	*Ambystoma jeffersonianum*	20	13.0
Seal salamander	*Desmognathus monticola*	1	3.6
Allegheny mountain dusky salamander	*Desmognathus ochroepheus*	1	5.8
Long-tailed salamander	*Eurycea longicauda*	1	10.1
New Jersey chorus frog	*Pseudacris* feriarum kalmi	1	12.3
Eastern spadefoot	*Scaphiopus holbrooki*	1	15.9
Northern dusky salamander	*Desmognathus fuscus*	1	44.2
Northern red salamander	*Pseudotriton r. ruber*	1	44.9

Habitat Preference

Although the species accounts are grouped by breeding habitat, conservation of amphibians requires a complete understanding of not only breeding habitat, but all of the habitats utilized during each stage of life-history. Effective conservation actions require approaches that provide protection (in some cases restoration) for all of these habitats. Therefore, a more detailed description of the specific habitats utilized during all life history stages is presented for each species.

Threats

When at all possible, threats reported for the GCN amphibian species are reported based on threats taken from the literature. However, due to the relative dearth of knowledge on threats and stressors to many species (Stuart et al. 2004), threats may in some cases be inferred based on knowledge of known and suspected reasons for declines and the habitat requirements and tolerances of the species. Two factors including illegal collection and possession and the introduction of predatory species (typically fishes and amphibians) present widespread threats to Maryland amphibians. These and other threats usually correspond to human related activities. Land use change due to human activities from 1973 to 2000 in each of Maryland's 8-digit watersheds along with the number of GCN amphibian and reptile species in each watershed are shown in Table 2. Both reptiles and amphibians are included on this list to show the extent of threats to herpetofauna in general. All watersheds with GCN species showed increases in urban land use. Stronghold watersheds for any reptile or amphibian species are highlighted on the table.

Conservation Needs

We suggest conservation and monitoring needs for species based on available knowledge of threats and current human activities in areas known to inhabit species. At a minimum, we recommend conserving the habitats that the species utilizes during each stage of its life history. Whether or not it is specifically written for each species, the regulations regarding the illegal collection and possession of amphibians need to be enforced for all species. Another universal conservation need is the need to have the state wetland laws amended to protect all amphibians that require a mix of aquatic and terrestrial habitats to survive. Conservation for species that occur on state owned lands could be facilitated by incorporating conservation initiatives into the management plans for these areas.

Monitoring Needs

Basic monitoring data for many Maryland amphibians are severely lacking. Five monitoring needs are important to every amphibian species: 1) define the complete extent of the species distribution in Maryland as accurately as possible by continuing to survey areas with potentially suitable habitat for the species; 2) survey additional, unexplored, areas where potentially suitable habitat may exist for the species; 3) monitor existing populations (particularly in areas of species strongholds) so that widespread declines can be detected; 4) collect substantial concomitant environmental data to describe conditions coincident with the current status of Maryland's populations and to explain any changes in the status that may occur; 5) develop more complete understandings of the life history and demographics.

Table 2. Urban land use from 1973 to 2000, along with land use change and the number of GCN reptile and amphibian species. Stronghold watersheds are highlighted in gray.

Maryland 8-digit Watershed (stronghold watersheds highlighted)	1973 (%)			2000 (%)			% Change Urban	GCN reptile and amphibian richness
	Agriculture	Forest	Urban	Agriculture	Forest	Urban		
Aberdeen Proving Ground	1.3	40.4	37.8	1.0	39.0	36.8	-1	0
Anacostia River	11.8	32.4	55.0	2.4	16.6	78.6	23.6	9
Antietam Creek	62.6	27.9	9.4	48.5	28.6	22.7	13.3	6
Assawoman Bay	16.8	11.9	11.6	12.5	13.2	14.6	3	0
Atkisson Reservoir	52.7	33.5	13.6	39.5	26.0	34.1	20.5	2
Back Creek	51.9	32.1	5.1	43.8	34	8.9	3.8	0
Back River	2.1	15.1	68.7	1.7	15.7	68	-0.7	0
Baltimore Harbor	3.5	18.3	50.7	1.5	12.9	56.9	6.2	0
Big Annemessex River	21.8	33.1	1.2	19	30.4	5.3	4.1	0
Big Elk Creek	51.8	41.8	6.2	47.6	39.5	12.5	6.3	3
Bird River	16.8	41.7	33.5	12.7	31.7	46	12.5	0
Bodkin Creek	5.2	58.7	23.5	4.1	42.6	39.5	16	0
Bohemia River	66.1	21.0	1.2	63.9	21.1	3.2	2.0	2
Breton Bay	26.4	60.3	4.6	23.0	54.3	13.4	8.8	4
Brighton Dam	62.1	33.0	2.9	49.4	33.5	15.1	12.2	2
Broad Creek	60.8	36.2	2.7	54.6	33.8	11.2	8.5	6
Bush River	19.6	42.1	14.6	16.0	37.9	20.6	6.0	6
Bynum Run	43.8	33.8	22.6	23.0	23.5	53.2	30.6	3
Cabin John Creek	2.4	22.8	74.5	0.8	12.6	86.5	12.0	7
Casselman River	27.0	69.3	2.2	25.4	65.8	7.3	5.1	14
Catoctin Creek	64.9	32.8	2.3	53.7	34.9	11.4	9.1	1
Chincoteague Bay	14.8	20.3	0.5	14.2	20.9	0.8	0.3	0
Christina River	60.6	24.8	16.4	50.4	22.5	27.1	10.7	0
Conewago Creek	65.2	34.2	1.5	58.8	25.6	15.5	14	0
Conococheague Creek	72.2	17.8	8.9	54.0	19.5	24.9	16.0	4
Conowingo Dam Susquehanna River	33.3	49.3	3.4	30.0	35.8	11.7	8.3	8
Corsica River	62.9	28.6	2.7	60.4	26.8	6.9	4.2	4
Deep Creek Lake	23.1	61.3	5.5	19.8	48.5	19.6	14.1	4
Deer Creek	62.0	34.1	4.0	55.5	31.8	12.4	8.4	4
Dividing Creek	19.7	79.6	0.0	20.1	77.5	1.7	1.7	4
Double Pipe Creek	78.5	17.0	4.4	68.9	19.3	11.7	7.3	4
Eastern Bay	17	6.4	3.0	12	5.1	8.6	5.6	0

Evitts Creek	21.2	69.1	8.7	13.8	66.6	18	9.3	0
Fifteen Mile Creek	5.7	94.4	0.0	5.4	92.6	2.0	2.0	5
Fishing Bay	10.4	32	0.6	11.1	30.7	1.7	1.1	0
Furnace Bay	46.8	43.8	5.6	40.3	41.4	14.3	8.7	3
Georges Creek	11.3	68.9	18.2	12.6	71.8	15.5	-2.7	0
Gilbert Swamp	38.3	59.4	1.4	33.2	52.5	13.1	11.7	0
Gunpowder River	4.5	25.8	19.5	2.6	23.8	22.6	3.1	3
Gwynns Falls	10.7	24.9	64.1	4.3	17.3	76	11.9	0
Honga River	4.2	15	1.4	3.8	15	2.4	1	0
Isle of Wight Bay	35.5	34.3	8.3	30.2	29.0	19.3	11.0	4
Jones Falls	12.7	27.7	58.9	8.9	16.4	73.1	14.2	0
Kent Island Bay	43.7	21.3	17.2	26.5	17.3	38.3	21.1	0
Kent Narrows	25.8	18.6	4.1	20.4	15	15	10.9	0
Langford Creek	64.5	21.4	1.1	62.7	20.9	3.4	2.3	0
Liberty Reservior	53.8	33.4	9.5	41.2	30.6	24.9	15.4	0
Licking Creek	20.6	79.5	0.1	17.5	78.6	3.7	3.6	0
Little Choptank	23.5	35.2	0.7	22	33	4.5	3.8	0
Little Conococheague River	58.2	40.1	1.5	48.0	40.9	10.9	9.4	3
Little Elk Creek	52.8	36.3	10.1	43.8	32.4	23	12.9	0
Little Gunpowder Falls	52.0	35.2	12.3	42.5	32.7	24.0	11.7	4
Little Patuxent River	26.0	45.3	28.3	12.7	37.0	49.8	21.5	7
Little Tonoloway River	33.8	64.4	1.9	24.3	67	8.2	6.3	0
Little Youghiogheny River	45.1	44.4	7.6	41.1	41.8	16.3	8.7	5
Loch Raven Reservior	45.4	42.9	9.9	37.8	37.8	21.7	11.8	0
Lower Chester River	26.7	15.0	2.3	26.2	12.9	4.9	2.6	1
Lower Choptank	32.7	15.4	4.3	33.8	13.4	9.8	5.5	0
Lower Elk River	34.3	37.3	2.9	33.2	35.9	5.7	2.8	0
Lower Gunpowder Falls	52	35.2	12.3	42.5	32.7	24	11.7	0
Lower Monocacy River	64.7	28.5	6.5	46.7	30.3	22.8	16.3	7
Lower Pocomoke River	35.1	57.9	3.0	33.7	57.4	4.6	1.6	8
Lower Susquehanna River	27.6	39.0	15.9	23.0	33.9	24.1	8.2	9
Lower Wicomico River	34.1	38.0	10.0	28.0	32.2	21.5	11.5	4

Lower Winters Run	28.8	50.4	18.5	16.2	40.2	40.8	22.3	1
Magothy River	5.5	33	41.3	2.2	22.7	54.1	12.8	0
Manokin River	24.9	37.6	1.4	23.5	36.5	4.6	3.2	4
Marsh Run	74.3	15.6	10.2	56.6	19.5	23.8	13.6	1
Marshyhope Creek	53.6	39.4	2.2	52.9	36.6	5.7	3.5	5
Mattawoman Creek	15.7	68.4	12.1	12.0	58.1	25.7	13.6	3
Middle Chesapeake Bay	0.2	0	0	0.3	0	0	0	0
Middle Chester River	73.9	13.2	4.5	71.5	11.9	8.3	3.8	3
Middle Patuxent River	55.2	37.5	7.2	36.3	28.5	35.0	27.8	1
Middle River - Browns	4.4	22	43.5	4.6	20.8	45	1.5	0
Miles River	47.2	25	5.3	42.2	21.4	13.8	8.5	0
Monie Bay	15.6	33.2	0.6	13.8	32.3	2.7	2.1	0
Nanjemoy Creek	15.6	71.9	3.2	14.7	69.4	6.7	3.5	2
Nanticoke River	31.8	38.5	1.5	31.3	36.8	4.6	3.1	6
Nassawango Creek	26.3	72.8	0.4	25.1	70.8	3.6	3.2	4
Newport Bay	31.3	36.7	4.6	24.8	35.7	9.4	4.8	0
Northeast River	39.0	43.5	8.1	33.3	39.6	17.6	9.5	5
Octoraro Creek	62.0	33.6	4.4	50.6	30.8	18.4	14.0	7
Oxon Creek	7	29.2	61.5	0.4	17	87.7	26.2	0
Patapsco River Lower North Branch	17.3	51.1	30.0	12.2	38.6	47.0	17.0	6
Patuxent River Lower	24.7	53.6	6.0	20.4	44.4	19.3	13.3	9
Patuxent River Middle	42.0	48.2	3.5	36.9	43.2	13.9	10.4	1
Patuxent River Upper	25.9	52.3	21.4	18.1	44.4	35.6	14.2	3
Piscataway Creek	18.1	55.8	23.6	14.2	43.0	39.5	15.9	5
Pocomoke Sound	20.7	32.7	0.3	19.4	31.3	3.6	3.3	4
Port Tobacco River	21.6	61.7	9.4	19.0	52.6	20.6	11.2	3
Potomac River AL County	11.3	83	0.3	9.6	83.3	1.6	1.3	0
Potomac River Frederick County	56.0	34.3	4.3	42.2	36.8	15.9	11.6	5
Potomac River Lower North Branch	14.0	75.8	8.7	11.4	73.8	13.6	4.9	11
Potomac River Lower Tidal	7.6	12.3	1.3	7.1	11.6	2.7	1.4	2
Potomac River Middle Tidal	3.6	35.8	2.9	3.2	34.1	5.1	2.2	1
Potomac River Montgomery County	40.6	32.2	20.6	25.7	29.0	37.3	16.7	11

Potomac River Upper North Branch	17.6	75.3	6.0	15.2	74.1	9.6	3.6	6
Potomac River Upper Tidal	7.0	39.2	29.8	4.4	26.6	41.9	12.1	5
Potomac River Washington County	42.0	47.7	2.6	33.8	46.5	12.5	9.9	5
Prettyboy Reservoir	54.2	37.6	5.0	45.8	36.8	14.1	9.1	5
Rock Creek	19	22.2	58.1	7.3	17.8	74.3	16.2	0
Rocky Gorge Dam	48.3	36.5	12.0	27.9	38.0	31.0	19.0	2
South Branch Patapsco	59.3	33	7.7	43.5	28.7	27	19.3	0
Sassafras River	57.9	24	2	55.9	23.5	4.2	2.2	0
Savage River	14.9	82.8	1.2	14.4	81.4	3.4	2.2	7
Seneca Creek	57.5	32.2	9.7	34.4	32.6	32.0	22.3	3
Severn River	11.4	43.5	30.4	8.4	30.6	45.9	15.5	0
Sidling Hill Creek	20.0	80.1	0.0	17.6	79.0	3.2	3.2	3
Sinepuxent Bay	10.8	20.6	3.2	6.2	17.2	12	8.8	0
South River	19.2	53.8	13.3	15.1	41.3	29.5	16.2	0
Southeast Creek	65.6	30.7	0.9	66.6	27.5	2.7	1.8	0
St. Clements Bay	37.2	48.7	3.1	34.6	45.7	8.5	5.4	0
St. Mary’s River	20.7	55.3	6.4	18.0	47.6	16.1	9.7	5
Stillpond-Fairlee	57.1	30.6	3.1	55	28	7.9	4.8	0
Swan Creek	40.9	36.9	17.5	31.7	32.5	30.7	13.2	2
Tangier Sound	1.2	1.5	1.7	0.8	1.2	2.5	0.8	0
Tonoloway Creek	30.8	64.1	5.6	18.7	64.9	15.5	9.9	0
Town Creek	18.7	80.9	0.4	19.3	78.4	2.3	1.9	3
Transquaking River	42.7	37.9	0.3	43.9	35.1	1.7	1.4	5
Tuckahoe Creek	69.1	28.6	0.6	68.5	26.2	3.6	3.0	4
Upper Chester River	63.6	33.3	1.3	63.7	30.9	3.3	2.0	6
Upper Choptank River	59.6	32.0	2.8	57.4	28.4	8.2	5.4	11
Upper Elk River	23.4	51.2	12.4	15.7	46.1	25.2	12.8	4
Upper Monocacy River	60.2	36.6	3.3	50.7	39.7	9.5	6.2	8
Upper Pocomoke River	44.2	55.2	0.7	43.6	52.3	4.0	3.3	7
West Chesapeake Bay	17.2	67.7	8.6	14	56.2	24.4	15.8	0
West River	33.1	39	9.1	29.4	36.3	15.4	6.3	0
Western Branch	33.1	48.9	17.4	15.0	39.3	42.5	25.1	3
Wicomico Creek	39.0	53.8	1.5	38.5	50.9	10.4	8.9	0

Wicomico River	31.2	44.2	1.8	27.7	40.6	7	5.2	4
Wicomico River Head	43.8	46.0	9.8	35.1	38.7	25.3	15.5	2
Wills Creek	11.7	74.5	13.7	9.0	73.4	17.5	3.8	7
Wye River	63.5	23.6	1.1	59.4	21.6	6.8	5.7	4
Youghiogheny River	29.4	68.7	1.1	25.6	65.8	7.5	6.4	14
Zekiah Swamp	26.5	67.5	5.6	22.1	58.0	18.1	12.5	5

GCN Species Accounts

Pond Breeding species

Almost half (8) of Maryland's 18 GCN amphibian species breed in lentic water environments (Table 3). Most of these species breed exclusively in relatively small (less than 4.0 hectares), usually temporary pools (vernal pools) or pools associated with seepage springs and shallow wetlands. The shallow and often temporary nature of these aquatic habitats prohibits the colonization of predatory fishes that prey on eggs and larval amphibians.

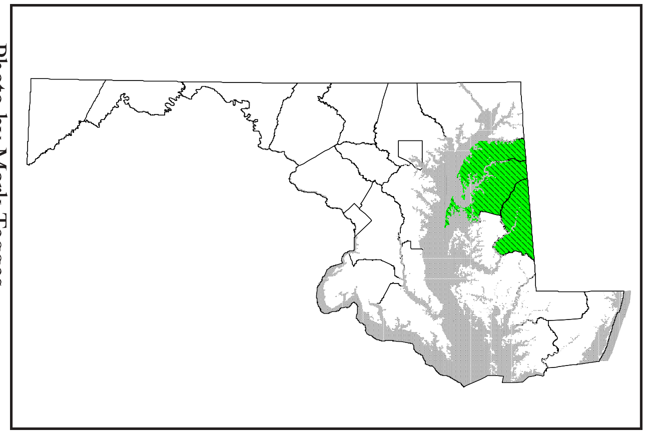
Although ponds and wetlands are the most obvious habitat types to protect to insure the conservation of most pond-breeding species, the terrestrial habitat utilized by pond breeding species must also be protected. Additionally, buffer zones surrounding the wetland habitats and terrestrial habitats must be protected to avoid potentially far reaching effects from physical alterations to adjacent landscapes (Semlitsch and Jensen 2001). When considering dispersal and metapopulation dynamics, avoiding extensive forest fragmentation is also important to these species because many may not travel even short distances through non-forested habitat (e.g. across power-line rights-of-way, roads, or fields; deMaynadier and Hunter 1999; Rotherermel and Semlitsch 2002).

Table 3. Maryland's eight GCN pond-breeding amphibian species listed in order by priority ranking score.

Species
Barking treefrog
Eastern narrow-mouthed toad
Eastern tiger salamander
Mountain chorus frog
Carpenter frog
Jefferson salamander
New Jersey chorus frog
Eastern spadefoot

Barking Treefrog (*Hyla gratiosa*)

Photo by Mark Tegges



Status Endangered

Distribution
The barking treefrog is restricted to the upper eastern shore (including portions of Kent, Queen Anne's, and Caroline Counties). Since this species was first discovered in Maryland in 1982 (Anderson and Dowling 1982), the historic distribution is not entirely clear. However, it was most likely much more widespread historically (White and White 2002).

Habitat Preference
The barking treefrog is found only in Coastal Plain woodland habitats in relatively close proximity to vernal pool locations. The barking treefrog breeds in medium to large, primarily fishless, vernal pools during the spring. During dry and cold conditions it retreats underground. During warm moist conditions, when it is not breeding, it is typically in trees or shrubs near breeding ponds (White and White 2002).

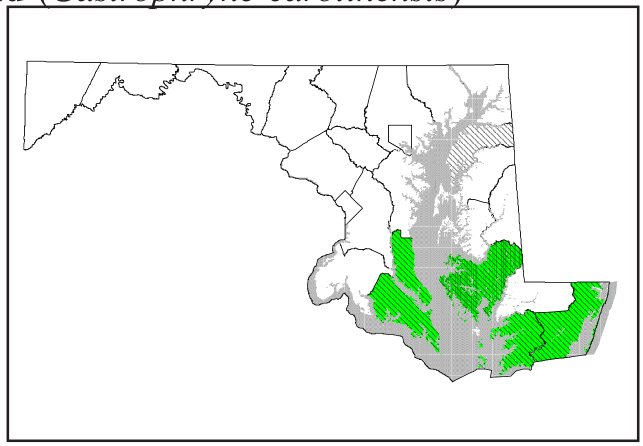
Threats
The barking treefrog is vulnerable to even minor habitat perturbations and stochastic events. As with other pond breeding species, loss of wetland breeding habitat and forested habitat are presumably the most important threats. Agriculture runoff, hydrologic disruption, and clearing of trees that surround breeding habitat also threaten this species.

Conservation Needs
This is probably the rarest pond-breeding amphibian in Maryland. Protection of breeding habitat, as well as adjacent forests, from development or desiccation due to forest fragmentation or farming is likely critical to the long term existence of this species in Maryland. Areas with existing populations could be included on Maryland's registry and should also be considered for land acquisition by land conservation organizations such as The Nature Conservancy.

Monitoring Needs
As this secretive species was only discovered in Maryland relatively recently, surveying adjacent areas for additional records should be ongoing and comprehensive. Monitoring the very small, disjunct populations that presently exist in Maryland is also important, as these types of insular populations are particularly susceptible to extirpation. Research is also needed to determine the most beneficial management practices to insure long-term sustainability and to determine specific breeding and non-breeding habitat requirements in Maryland.

Eastern Narrow-mouthed Toad (*Gastrophryne carolinensis*)

Photo by Mark Tegges



Status Endangered

Distribution
The eastern narrow-mouthed toad is sparsely distributed in portions of Maryland's Coastal Plain. This represents the northern extent of the species range in the United States.

Habitat Preference
The eastern narrow-mouthed toad utilizes wetlands, floodplains, marshes, swamps, and vernal pools in both open and forested areas for breeding. It is difficult to determine exactly when breeding will occur for the eastern narrow-mouthed toad. Breeding usually consists of explosive congregations during late spring or early summer in Maryland (White and White 2002). Adults outside the breeding season require adequate cover and the presence of areas surrounding the preferred aquatic habitat where they can burrow (White and White 2002).

Threats
There is a dearth of knowledge regarding this species and reasons for its apparent rarity in Maryland. However, since Maryland's eastern narrow-mouthed toads are at the margin of their geographic extent, they are likely to already be living in conditions that are marginally tolerable. They are, therefore, likely to be particularly susceptible to even minor anthropogenic alterations to the habitat or surrounding environmental conditions where they occur. Destruction and degradation of wetlands, vernal pools, and floodplain habitats are particularly threatening to this species.

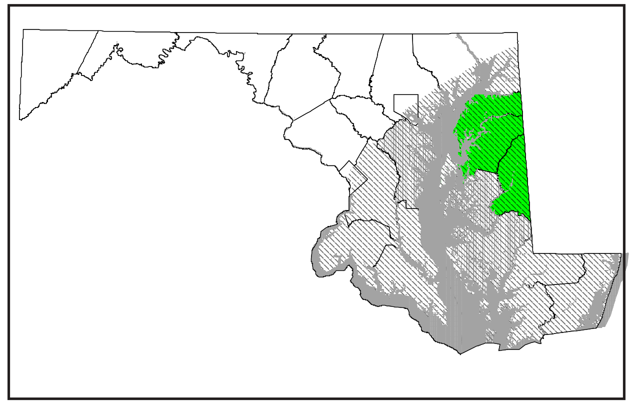
Conservation Needs
Protection of breeding habitats and adjacent areas from anthropogenic influences and destruction is an obvious necessity. As occurrences of this species have been recorded on state owned lands, population protection measures should be incorporated into the management plans for these areas. Due to the rampant illegal possession and trade of this and other rare species, state regulations prohibiting these activities must be enforced.

Monitoring Needs
Due to the scarcity of information on narrow-mouthed toads in Maryland, surveys aimed at better defining the present distribution as well as associated habitat and water quality conditions would be extremely useful in planning effective conservation strategies.

Eastern Tiger Salamander

(*Ambystoma tigrinum tigrinum*)

Photo by Mark Tegges



Status Endangered

Distribution

Historically the eastern tiger salamander was distributed throughout the Coastal Plain of Maryland. As recently as the 1960's it was documented in nearly every county on the eastern shore and two counties on the western shore Coastal Plain. It is now restricted to small areas within Kent, Quenn Ann, and Caroline Counties.

Habitat Preference

In Maryland, the eastern tiger salamander breeds during November - April. Larvae metamorphose into adults during June – August and may move hundreds of meters from the breeding pond (Petranka 1998). Adults and juveniles typically spend the majority of their time in underground burrows except during the breeding season. As a result, the tiger salamander prefers areas with loose soil for burrowing. Many types of temporary and permanent lentic habitats are utilized for breeding. Neutral pH is preferred and acidic water (pH <5.0) in breeding ponds affects the survival, growth and development of eggs and larvae (Whiteman *et al*. 1995). The absence of predatory fish is also important as many fishes feed on larval tiger salamanders. These salamanders are so attractive to fish that they are sold as bait in some areas of the western United States (Espinoza 1970; Collins 198; Petranka 1998).

Threats

A current lack of distribution and demographic data for the species prohibits comprehensive conservation. Deforestation, urbanization, loss of wetland habitat, fish stocking, the expansion of the bullfrog (*Rana catesbeiana*) population, and acid precipitation are likely the most pervasive stressors to eastern tiger salamanders in Maryland. Certain recreational activities (e.g. off road vehicle use) jeopardize terrestrial habitats. Mosquito control initiatives, such as application of larvicides and biological control, threaten breeding habitat. Since the current number of sutiable habitat sites for breeding are few and dwindling, the successional change of these open canopy seasonal wetland habitats also threatens the species.

Conservation Needs

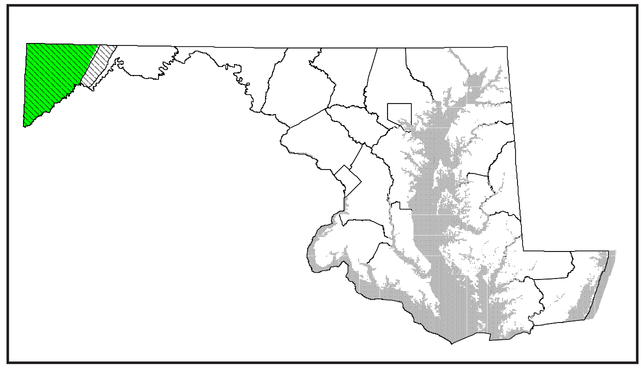
Wetland habitats and forested areas surrounding wetlands must be protected. A minimum buffer of 200 meters surrounding known breeding wetlands warrants protection. Forested corridors linking ponds are needed to insure the maintenance of metapopulation dynamics. Reducing sources of acid inputs to breeding ponds is also important. Fish stocking and draining of breeding ponds as well as preventing the threat of contamination of native populations by the importation of larvae from the mid-west for fish bait must be avoided.

Eastern Tiger Salamander (continued)

Monitoring Needs

Many of the few existing breeding locations for eastern tiger salamanders are known. However, other suitable wetlands, including vernal pools, on the eastern shore that may be suitable should be identified and investigated. Long term monitoring of known eastern salamander populations as well as other wetland and forested habitats in their range should continue to be conducted. Goals of population studies should include, determining population size, home range, reproductive output, and recruitment rate. Developing an understanding of the effect of pH on egg and larval development and survival is also needed.

Mountain Chorus Frog (*Pseudacris brachyphona*)



Status Threatened

Distribution
In Maryland, mountain chorus frogs are only found in isolated areas of the west.

Habitat Preference
Like most of Maryland's GCN amphibians, the mountain chorus frog is a spring breeder. However, it may be periodically active above ground throughout the summer (especially following significant rainfall) and hibernates underground during fall and winter (Hulse *et al*. 2001). The mountain chorus frog utilizes forested habitat to a larger degree than any other Maryland GCN species and may be found a long way from breeding habitats. Breeding habitats consist of shallow woodland ponds, roadside ditches, and seepage springs. Breeding ponds can be as small as two square meters (Hulse *et al*. 2001).

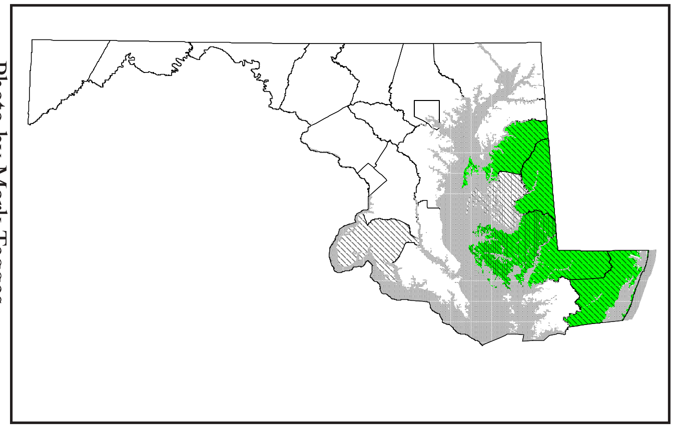
Threats
Recent and widespread declines have been documented throughout the mountain chorus frog range, including Maryland. The mountain chorus frog historically occurred at a large number of sites in western Pennsylvania. However, no occurrences have been reported for over 20 years (Hulse *et al.* 2001). Despite these pervasive declines, little information is available on specific stressors and threats to mountain chorus frogs. Acidic deposition is a likely candidate cause because of the low buffering capacity of the soils in much of the highlands area where the species occurs. Habitat (including wetland and forest) alteration and elimination as a result of logging, road construction, road maintenance, and silt and salt runoff are important stressors to mountain chorus frogs in Maryland.

Conservation Needs
In areas known to harbor this species, road builders and maintenance crews should be notified regarding the importance of nondescript wetlands (e.g. mud puddles along roads) as breeding habitat for this species. A roadside management agreement, aimed at protecting roadside breeding sites during the spring breeding season, should be pursued. Breeding habitat may be constructed by instructing timber operators to create (or at least not fill) ditches on skid roads. Habitat and population protection measures should be incorporated into Maryland state forest management plans.

Monitoring Needs
Due to the enigmatic decline of this species, information regarding changes in the environmental or habitat conditions in places where declines are occurring would be extremely useful in planning effective conservations actions. Associated habitat and chemistry data from ponds where successful breeding occurs would also be useful. Historical localities should be surveyed for extant populations in addition to continue efforts to locate additional populations. The possible limitation of preferred breeding habitat and reproductive success at all breeding sites should be investigated.

Carpenter Frog (*Rana virgatipes*)

Photo by Mark Tegges



Status In Need of Conservation

Distribution
The distribution of the carpenter frog consists of isolated portions of several eastern shore counties including Queen Anne's, Caroline, Talbot, Dorchester, Worchester, and Wicomico.

Habitat Preference
Like other true frogs (family Ranidae), the carpenter frog is active throughout the warm months of the year. However, the carpenter frog prefers to inhabit and reproduce in wetlands that are typically too acidic for other ranid species (Given 1999) including sphagnum bogs, swamps, and Delmarva Bays (White and White 2002). Unlike Maryland's other GCN pond-breeding amphibians, it is always found in close association with aquatic habitat. Breeding typically begins in April and may continue through July (White and White 2002).

Threats
Data are needed regarding the ecology, life history, and habitat requirements to plan effective conservation of the carpenter frog in Maryland. Habitat degradation and loss, forest fragmentation and elimination are obvious threats. Due to its dependence on acidic wetlands, the carpenter frog is threatened by the pervasive liming of historically acidic soils for the purpose of agricultural production. Important habitats are also drained for agriculture and logging. Biotic interactions are also important to this species including competition and predation from conspecifics such as green frogs and bullfrogs as well as predatory fishes. As with many other species, illegal collection and possession of this species present a threat.

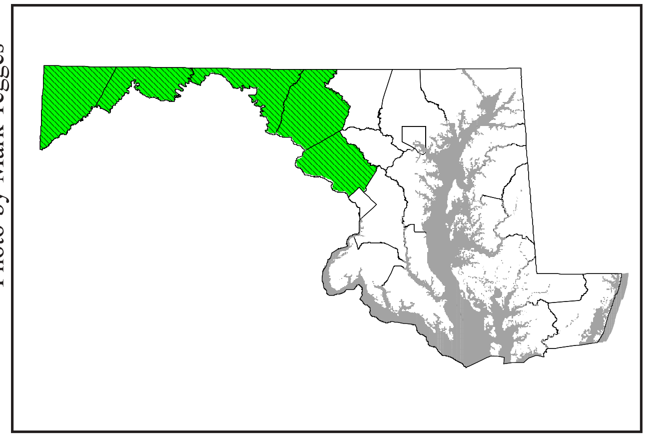
Conservation Needs
A regional planning effort should be implemented that examines core populations and linkages between them from a landscape perspective to ensure the future of viable and genetically diverse populations. The preservation of acidic swamps and wetlands is critical to the maintenance of carpenter frog and other acid endemic species in Maryland. Farmland adjacent to acidic swamps should be purchased and taken out of cultivation to reduce the affect of liming on these systems. Insuring the exclusion of cosmopolitan and non-native invader species of amphibians and fishes is also important. Forest management practices that improve habitat suitability should be identified and implemented. Wetland habitats suitable to carpenter frogs could be constructed or restored on commercially forested lands.

Monitoring Needs

The carpenter frog is very secretive. Extensive monitoring of swamps bogs and wetlands of the eastern shore is likely to reveal new records for this species. Monitoring the effects of liming on specific wetland habitats is also an important component of understanding the current and historic distribution of, and threats to carpenter frogs in Maryland. Research needs include studies of the hibernation ecology, the effects of invasive species (fishes and other ranid species) on abundance and population viability, basic life history and demographic investigations, and landscape attributes necessary to allow persistence.

Jefferson Salamander (*Ambystoma jeffersonianum*)

Photo by Mark Tegges



Status Watch List

Distribution
In Maryland, the Jefferson salamander can be found within the Piedmont and Highland portions of the Potomac River Drainage, from Montgomery to Garrett Counties.

Habitat Preference
Breeding occurs between mid-February and the end of the first week of March in Maryland (Stranko et al. 2004). Adults are rarely seen outside the breeding season and presumably spend most of their time underground. Adults and juveniles have been found to be abundant near the surface, under logs and bark during the fall, well outside the breeding season. Adults and juveniles can utilize forested habitats hundreds of meters from breeding ponds (Petranka 1998). Preferred breeding sites are fishless, ephemeral and permanent ponds with abundant vegetation and moderate to high pH (Thompson et al. 1980; Thompson and Gates 1982). Although the use of ponds in flood plain areas occurs, Jefferson salamanders more often use upland ponds.

Threats
Although most of Maryland's amphibians are intolerant of acidity, the Jefferson salamander appears to be one of the most vulnerable, with complete egg mortality occurring at pH less than 4.5 (Petranka 1998). Other threats include, habitat fragmentation, loss or degradation of vernal pool and adjacent upland habitats, urban development, logging, pesticides, and road runoff.

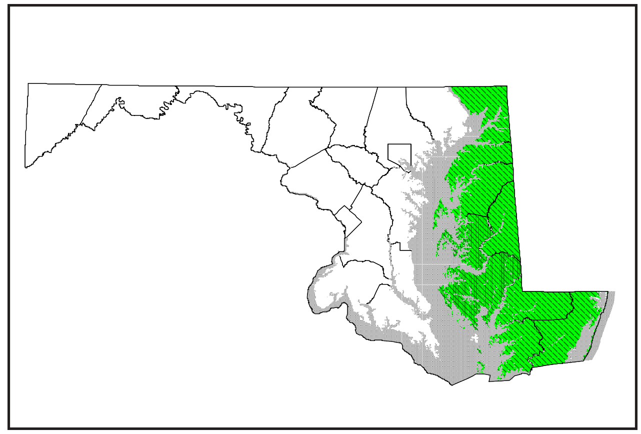
Conservation Needs
Preserving forested areas and wetland habitats, where acidity is relatively low, are important considerations for maintaining Jefferson salamander populations. Habitat alterations, such as new housing or road construction, or logging, should be prevented within 150 to 250 meters of breeding sites.

Monitoring Needs
Recently, the known extent of the Jefferson salamander distribution in Maryland was expanded to include areas east of the Catoctin Mountains (Stranko et al. 2004). This expansion added several sites in Montgomery and Frederick Counties. Additional monitoring should be conducted, especially in the area east of the Catoctin Mountains, to better describe the complete distribution of this species. In addition, stronghold areas should continue to be monitored to track potential declines. Research needs include biochemical analyses of specimens in areas where the genetic composition of populations is unknown, determining the landscape requirements for viable populations and identify variables that describe quality upland habitat, and investigating the effect of acid deposition on embryonic mortality.

New Jersey Chorus Frog

(Pseudacris feriarum kalmi)

Photo by Mark Tegges



Status GCN

Distribution

The New Jersey chorus frog is found sparsely distributed throughout the eastern shore of Maryland.

Habitat Preference

The New Jersey chorus frog is one of the earliest breeding amphibians in Maryland. It often begins breeding in mid-February with transformed frogs sometimes leaving ponds in the early spring (Hulse *et al.* 2001; White and White 2002). The New Jersey chorus frog is secretive and is not typically encountered except during the breeding season. Shallow, grassy wetlands and woodlands, typically with ephemeral aquatic habitat are preferred breeding sites (White and White 2002). The adjacent terrestrial wooded areas are presumably utilized as retreats outside of the breeding period.

Threats

Loss of wetland and wooded habitats are the most pervasive threats to New Jersey chorus frogs in Maryland.

Conservation Needs

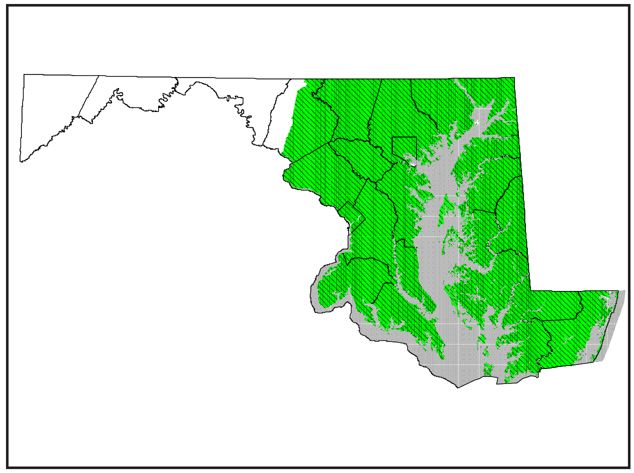
Conserving wetland habitats as breeding sites and adjacent (unfragmented) forested areas for adults to inhabit during other times of the year are important in maintaining existing New Jersey chorus frog populations.

Monitoring Needs

Exploration of potential breeding habitat, either by listening for calls or looking for breeding adults, during the late winter and early spring is needed to better define specific areas where New Jersey chorus frogs reside. Although many areas would be expected to be dry during the summer, surveys aimed at identifying additional potential breeding habitat (shallow vernal pools) should also be conducted and could take place during other times of the year.

Eastern Spadefoot (*Scaphiopus holbrookii*)

Photo by Mark Tegges



Status GCN

Distribution
The distribution of the eastern spadefoot in Maryland includes the Coastal Plain as well as most of the Piedmont. However, actual records are sparsely distributed throughout this region.

Habitat Preference
The eastern spadefoot is an explosive breeder. Breeding may occur on any given night, during spring, summer, or fall, following heavy rain and low barometric pressure (White and White 2002). Eggs hatch usually within two or three days and tadpoles metamorphose within as little as two weeks (Green and Pauley 1987). The eastern spadefoot adult is extremely proficient at burrowing and spends most of its time underground near vernal pools. The presence of small vernal pools and relatively loose soil for burrowing are critical to this species. However due to the rapid development of eggs and larvae, pools do not need to hold water for a long period of time to allow for successful reproduction. The eastern spadefoot has been reported to use wetlands in somewhat degraded and anthropogenically influenced areas (Whte and Whtie 2002). Adults typically burrow short distances from breeding ponds although they may occasionally forage during humid nights further from these habitats (Pearson 1955).

Threats
The elimination of wetland habitats, especially vernal pools, and habitat fragmentation to allow urban development and agricultural production, and pesticide application are the most obvious threats to the eastern spadefoot.

Conservation Needs
The most important consideration for conservation of the eastern spadefoot in Maryland is probably protection of vernal pool habitats in areas with loose soil for burrowing.

Monitoring Needs
Due to the patchy nature of current spadefoot records within its distribution. Surveys of potential breeding locations, which could include even small depressions that can temporarily hold water, following heavy rains should be conducted. As with other GCN species, monitoring strongholds or other areas with stable populations is necessary to detect possible causes for wide-scale declines that may occur. Studies on the effect of habitat fragmentation and on habitat use at a landscape scale are also needed.

Stream- dependent species

Eight of the 18 GCN amphibian species breed in lotic water environments (Table 4). These species can be found throughout the continuum of stream sizes from seepages to large rivers. All stream dependent species complete the larval stage of development in lotic water. Two species (common mudpuppy and eastern hellbender) complete all life stages underwater. Since they are obliged to stay in the stream, these species may be most susceptible to human related alterations to a stream's biological, chemical, and physical conditions. Most of Maryland's GCN amphibian species (with the exception of the eastern hellbender) attach their eggs to substrates. Depending on the species, the eggs may be laid under water or may hang above or near the water's surface from the under surface of a rock, log or other suitable structure.

Over half the streams in Maryland are in poor condition and no streams are free from anthropogenic influence. Stream-dependent amphibians are adversely affected by many of the same factors that influence other stream dwelling biota. Examples from recent studies demonstrating effects include sedimentation (Lowe et al. 2004), siltation and channelization (Smith and Grossman 2003), herbicides (Rohr et al. 2004), timber harvest (Corn et al. 2003), and impervious land cover (Boward et al. 1999; Willson and Dorcas 2003). See the stream -dependent species accounts in this report for more information regarding the influences of human activities on species richness as well as on the distribution of each species.

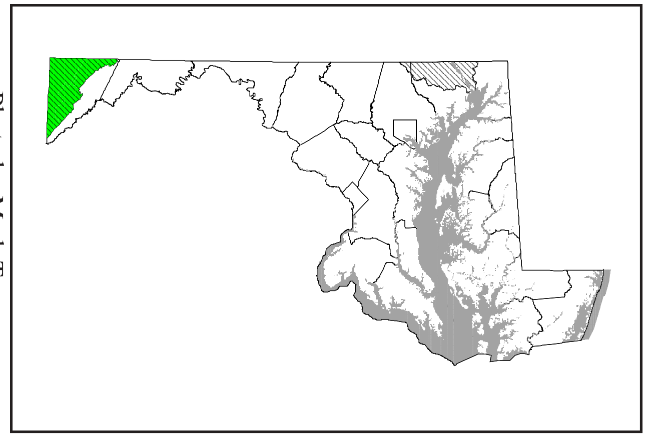
The protection of streams and riparian areas has obvious importance to the conservation of stream dwelling amphibians. However, landscape conditions throughout a stream's entire watershed are integrally linked to the stream's physical and chemical condition. Therefore, the protection at all three scales (in stream, riparian, and watershed landscape) must be considered when planning effective conservation for stream dwelling amphibians. Introduced species (usually fishes) also negatively influence stream dwelling amphibians through both predation and competition (Sih et al. 1992;Resetarits 1997). Stream blockages such as road culverts, pipe crossings, cement channels, and dams road crossings may also affect dispersal and metapopulation dynamics of many species.

Table 4. Maryland's eight GCN stream dwelling amphibian species listed in order by priority ranking score.

Species
Eastern hellbender
Common mudpuppy
Eastern mud salamander
Long-tailed salamander
Seal salamander
Allegheny mountain dusky salamander
Northern dusky salamander
Northern red salamander

Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*)

Photo by Mark Tegges



Status Endangered

Distribution
In Maryland, the eastern hellbender is restricted to living in a few large streams and rivers in far western and, historically, northeastern portions of Maryland.

Life History
The eastern hellbender spends its entire life underwater where it feeds primarily on crayfish and small fish (Bishop 1941; Swanson 1948). Breeding typically occurs during August and September and takes place in depressions under large rocks. Large streams and rivers with boulders and flat rocks for cover in fast flowing areas are the preferred habitats for eastern hellbenders (Taber et al. 1975, Nickerson and Mays 1973).

Threats
A number of studies (e.g. Bury et al. 1980; Dundee 1971; Gates et al. 1985; and McCoy 1982; and others) have implicated many of the same pervasive stressors that are attributed to declines in other stream dwelling biota (i.e. impoundments; pollution, and siltation) to eastern hellbender declines. Other threats include, direct habitat destruction via stream modification, eradication by anglers, and illegal collection.

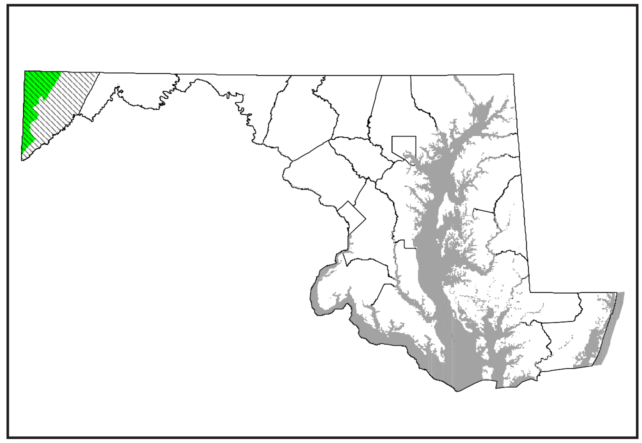
Conservation Needs
The continued degradation of large rivers and streams as demands from a rapidly growing human population increase will make conservation difficult. However, reducing the amount of pollution and siltation that occurs with urban development and logging is likely to be the only option that may be even minimally successful. In the vicinity of sites where hellbender populations exist, all logging, mining, road and bridge construction and maintenance, agriculture and urban runoff, damming and pollution should be restricted. Other activities that should be restricted include gigging, boulder removal, and collecting. Efforts to educate anglers on hellbender habitat requirements, sensitivity to stream modification and general biology are important to insure that hellbender habitat requirements are considered along with game fish habitat enhancement or restoration initiatives.
Eastern Hellbender (continued)

Monitoring Needs

Effective low impact methods (e.g. underwater cameras) for sampling for hellbenders are needed. Surveys within the potential hellbender range are necessary to comprehensively define its distribution. Extant hellbender populations must also be tracked over time to detect possible population size and demographic changes in association with physical, chemical, and landscape conditions. Specific research should focus on how water quality degradation, gypsy moth spraying, siltation, acid mine drainage, and acid precipitation affect this species. The effect of water quality degradation on reproductive potential may be particularly important. Biotic interactions such as the possible impacts of non-native introductions on hellbenders need to be investigated before non-natives are introduced.

Common Mudpuppy (*Necturus maculosus maculosus*)

Photo by Arther Hulse



Status Endangered

Distribution
The common mudpuppy has a similar geographic distribution to the eastern hellbender. In Maryland, it consists of large streams and rivers in far western Maryland.

Life History
Like the eastern hellbender, the common mudpuppy spends its entire life underwater in large streams and rivers. In other parts of its range it inhabits many different types of aquatic habitats including lakes, ponds, and large fast-flowing rivers (Petranka 1998). It is a generalized feeder and eats invertebrates, crayfish, and small fishes (Cochran and Lyons 1985). Based on the timing of breeding in nearby states (Bishop 1941), breeding presumably takes place in May or June in Maryland. Eggs are attached to the underside of cover objects such as logs, rocks, or boards.

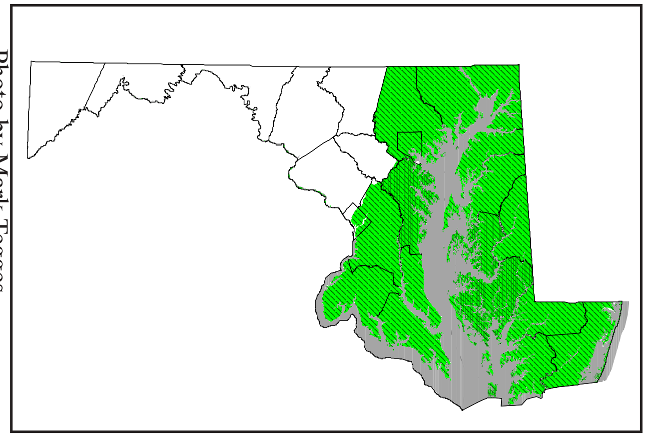
Threats
The common mudpuppy is considered to be much more tolerant of aquatic degradation compared with the eastern hellbender (Petranka 1998). However, since the two species inhabit similar habitat in Maryland, it may be negatively affected by many of the same factors that are responsible for hellbender declines.

Conservation Needs
Although protecting large rivers and streams from additional siltation and pollution is extremely difficult it may be the only effective way to conserve this and other important species that inhabit these systems. If water quality conditions improve re-stocking this species could be considered.

Monitoring Needs
Appropriate habitat should be comprehensively surveyed to determine whether any populations of common mudpuppy still exist in Maryland. The influence of non-native fish introductions should also be investigated.

Eastern Mud Salamander (*Pseudotriton montanus montanus*)

Photo by Mark Tegges



Status GCN

Distribution
The species is exceedingly rare in Maryland and, although the general area that it inhabits still covers the entire Coastal Plain and portions of the Piedmont, it appears to be found in many fewer places currently compared to historically (Harris 1975).

Habitat Preference
The eastern mud salamander spends its entire life in, or in close proximity to, the aquatic environment. As an adult, it lives in muddy habitats next to springs, streams, and swamps in bottomland forests. The greatest distance from water that an eastern mud salamander has been found was approximately 20 m (Petranka 1998). Eastern mud salamander nests have only rarely been found. They are located in cryptic underground sites in or near water. Eggs are presumably laid in the fall or early winter and hatch during winter. The larvae are fully aquatic and metamorphose into adult form approximately 15-17 months after hatching (Bruce 1974). Adults are lungless and rely on humid environments in or near water to facilitate cutaneous respiration.

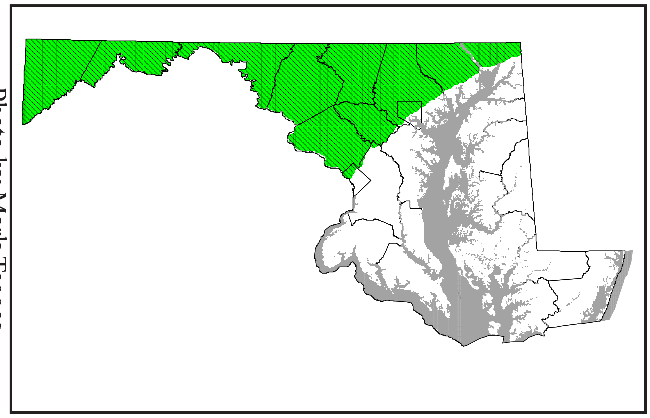
Threats
The eastern mud salamander is threatened by a lack of understanding regarding its life history, distribution, and demographics. It is most likely threatened by many of the same human- related influences to Coastal Plain streams.

Conservation Needs
Due to the rarity of this species, protection from human activities in areas where it is known to is paramount. A better understanding its ecology is needed to develop the most effective strategies for this species.

Monitoring Needs
Due to the current lack of knowledge on this species a great deal of monitoring data are needed. Monitoring potential habitats to better describe its distribution is extremely important. Understanding the needs of this species for breeding and feeding habitat as well as life history and demography are also important.

Long-tailed Salamander (*Eurycea longicauda longicauda*)

Photo by Mark Tegges



Status GCN

Distribution
The long-tailed salamander is found throughout the Piedmont and western Maryland.

Habitat Preference
Adults of this species prefer stream-side habitats where abundant cover, such as rocks and logs, are available. Shale banks, mines, and caves are also utilized. Larvae are typically found in small and moderate sized streams. However, young have also been found in underground seeps, and caves. Franz and Harris (1965) reported finding them in a Maryland reservoir.

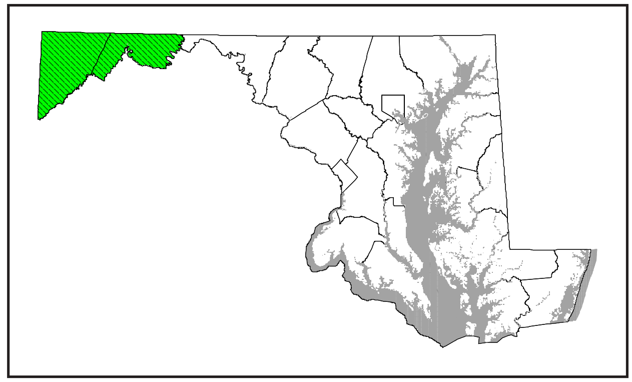
Threats
The most pervasive stressors to long-tailed salamanders appear to be urbanization, acidity, and nutrient pollution (as measured by nitrate nitrogen concentrations).

Conservation Needs
The persistence of this species requires the protection of streams and riparian areas where this species resides from pollution, development, logging, road construction, and mining. Adequate forested buffers must be maintained in areas where long-tailed salamanders are found.

Monitoring Needs
Monitoring is needed to determine the effect and extent of the loss of seepage areas, especially in small tributaries, due to increased beaver populations and human influences. Faunal inventories of seepage areas and basic life history and distribution studies are also needed.

Seal Salamander (*Desmognathus monticola*)

Photo by Jay Kilian



Status GCN

Distribution

The seal salamander is restricted to small, headwater streams and seeps in far western Maryland

Habitat Preference
The seal salamander is found in and around rocky mountain streams with well-aerated, cool water (Mount 1975; Krysik 1979). The species prefers hardwood forested areas and has not been collected by MBSS at any site with impervious land cover greater than 0.3%. Eggs are laid in or near running water. They may often be underground where water percolates through banks. Larvae live in water for approximately 8-11 months. Adults reside along streams and do not typically travel far from the edge.

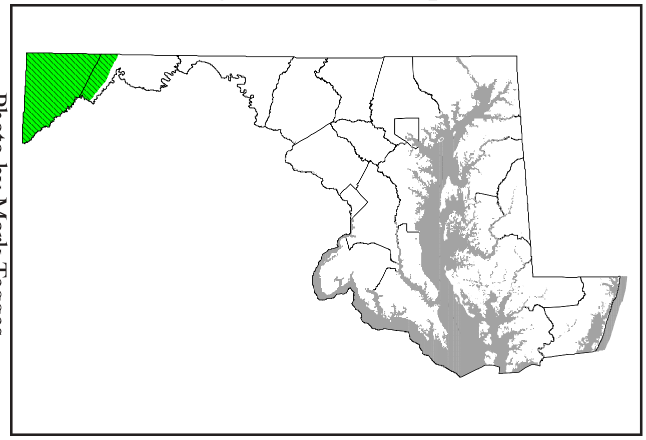
Threats
Human disturbances to forested mountain streams appear to be detrimental to this species in Maryland. In addition to only being found where urbanization and impervious land cover are extremely low, this species is also found only in or near streams with forested riparian buffers and more than half of the catchment forested.

Conservation Needs
This species requires protection of mountain streams, riparian areas and watersheds from land use alterations. Road crossings, mining, pollution, and logging are also likely to be detrimental to this species.

Monitoring Needs
Monitoring is needed in small mountain streams and seeps in heavily forested areas. Tracking of populations as development pressures increase is also necessary to verify the apparent sensitivities as indicated by MBSS data.

Allegheny Mountain Dusky Salamander (*Desmognathus ochrophaeus*)

Photo by Mark Tegges



Status GCN

Distribution
Like the seal salamander, this species is restricted to small, headwater streams and seeps in far western Maryland

Habitat Preference
The seal salamander is found in and around rocky mountain streams in western Maryland. Eggs are laid underground, along stream banks, or under substrates in mud (Wood and Wood 1955; Orr 1989). They may sometimes nest far from the stream bank (Wood and Wood 1955). Larvae live in seepages and small streams for a few weeks to several months (Keen and Orr 1980). The adults may be found close to streams or long distances from stream banks. The distance from the stream bank where they are found is related to the presence of other species of larger stream salamanders that readily out-compete and prey on this relatively small species

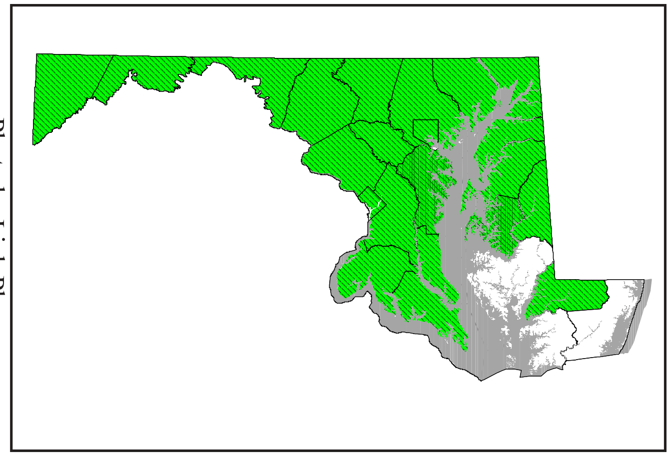
Threats
This species does not appear to be as sensitive to human disturbance as the seal salamander. However, MBSS data indicate that it does appear to be influenced by alteration to stream habitat quality and forested riparian areas.

Conservation Needs
This species requires protection of mountain streams, and seeps. Since this species also utilizes habitat that can be far from the stream, protection of riparian areas may be particularly important.

Monitoring Needs
Since they both occupy the same general habitats, monitoring needs for this species are similar to those for the seal salamander. Specifically, monitoring is needed in small mountain streams and seeps in heavily forested areas. Tracking of populations as human related impacts to mountain streams increase is also necessary to verify the apparent sensitivities as seen with the MBSS.

Northern Dusky Salamander (*Desmognathus fuscus*)

Photo by Linh Phu



Status GCN

Distribution
The northern dusky salamander is found throughout most of Maryland, but is much less common on the Coastal Plain.

Habitat Preference
Northern dusky salamanders are found in and near small, medium, and occasionally large streams. They appear to prefer rocky streams, but are occasionally found in streams with sandy substrates. Eggs are laid in or near streams (sometimes underground). The eggs hang from the under-surface of rocks or other substrates in a grape-like formation. Larvae live in streams or seeps for about nine months (Jutterbock 1990). Adults reside streamside and are often found under substrates during the day.

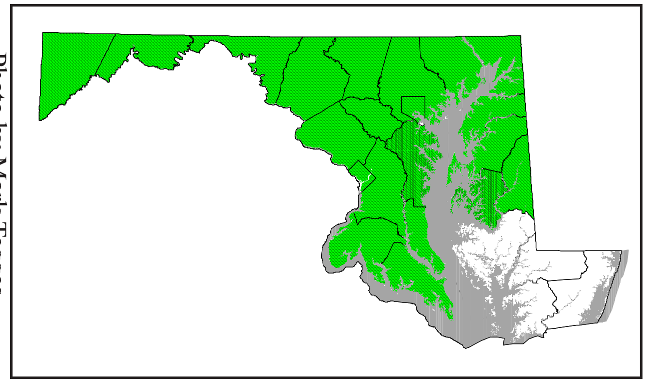
Threats
This species is sensitive to coal mining, siltation, and high metal concentrations (Gore 1983). Urbanization, scouring, and loss of ground cover are also important stressors (Orser and Shure 1972).

Conservation Needs
Like other stream salamanders, this species requires protection of streams from human activities that may cause siltation, pollution, increased acidity, or degradation of instream and riparian physical habitat structure.

Monitoring Needs
Historic records of northern dusky salamander on the Coastal Plain should be verified, especially at sites where larval identification was used to document the presence of this species, as larval northern two-lined salamanders closely resemble larval northern dusky salamanders. This species has been found by MBSS in streams with moderate human influences. However, additional monitoring is needed to document its sensitivity.

Northern Red salamander (*Pseudotriton ruber ruber*)

Photo by Mark Tegges



Status GCN

Distribution
The northern red salamander is found on the Coastal Plain, Piedmont and western portions of Maryland. It is, however, rarely encountered on the eastern shore.

Habitat Preference
Northern red salamanders prefer small rocky streams and springs. Larvae are often associated with pools where leaves, bottom debris, and plants are abundant (Bishop 1941). The larval period is approximately one year in length. Adults can be found in and around stream habitats and in underground burrows.

Threats
Deforestation, coal mining, stream siltation, pollution (Petranka 1998) and urbanization have most likely resulted in the loss of many local populations

Conservation Needs
As with other stream salamander species, protection of stream and riparian habitats, as well as stream catchments are important to this species.

Monitoring Needs
Although the northern red salamander is widely distributed in Maryland, it is found only sporadically. Monitoring that focuses on understanding the factors that determine the species presence would be useful in planning conservation.

Terrestrial amphibians

Most amphibians have an aquatic and terrestrial stage to their life history. However, several species of lungless salamanders (family *Plethodontidae*) do not have an aquatic larval stage. As the name implies, the lungless salamanders do not have lungs. They breathe through the skin and the lining of the mouth. They are secretive and spend their time in forested areas either underground or under substrates on the ground where they are safe from desiccation. Forest fragmentation, timber harvest, converting land from forest to agriculture or urban uses adversely affect terrestrial amphibians because of the drying effect that these activities have on the microhabitats that terrestrial amphibians inhabit. The dispersal and metapopulation dynamics of terrestrial amphibians are also likely to be affected by forest fragmentation and road construction.

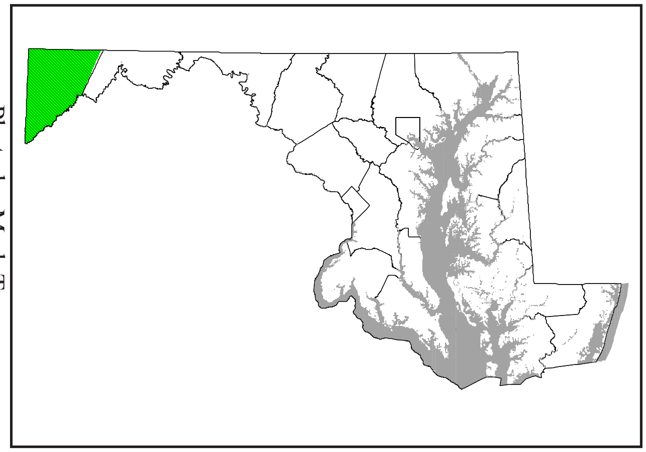
There are two species of entirely terrestrial GCN amphibians in Maryland (the green salamander and the Wehrle's salamander; Table 4).

Table 4. Maryland's two GCN entirely terrestrial species.

Green Salamander
Wehrle's Salamander

Green Salamander (*Aneides aeneus*)

Photo by Mark Tegges



Status Endangered

Distribution
The green salamander is restricted to far western Maryland.

Habitat Preference
The green salamander lives its entire life from, egg to adult, in rock crevices.

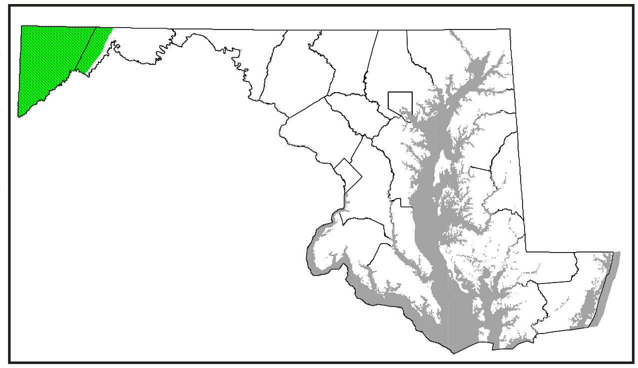
Threats
Logging and mining that occur in close proximity to rock crevices dries this microhabitat and may lead to extirpation (Petranka 1998). Sandstone mining may be particularly important as it directly affects the habitats for this species. Due to the paucity of suitable habitat available to this species in western Maryland, habitat fragmentation and land use changes are also presumably important threats. Collection of this species also provides a serious threat as a population could potentially be eradicated via excessive collecting once it is located.

Conservation Needs
To ensure maintenance of this species, a 100 meter protected perimeter surrounding rock outcrops that green salamanders currently inhabit should be established. No tree cutting (including canopy cutting) should be permitted within this area. The species should also be protected from excessive collection by enforcing existing state regulations on possession and trade of amphibians and reptiles.

Monitoring Needs
Since reasons for local population declines are enigmatic, studies of the life history, distribution, and demographics should be conducted. Research should also focus on the effect of habitat disturbance, especially commercial forestry and road construction near occupied habitat. The effect that habitat fragmentation of old growth forests has had on meta-population dynamics, such as gene flow, is also an important research need.

Wehrle's Salamander (*Plethodon wehrlei*)

Photo by Mark Tegges



Status In Need of Conservation

Distribution
The Wehrle's salamander is found exclusively in far western Maryland.

Habitat Preference
Wehrle's salamander inhabits forested hillsides in mountainous or hilly areas. This species prefers dryer habitats compared to other *Plethodon* species (Pauley 1978).

Threats
Wehrle's salamander is threatened by forestry practices that remove trees or the forest canopy that protects the microhabitats it inhabits. Due to the susceptibility and propensity of western Maryland forested areas to acid deposition impacts, it is another important threat to consider for this species.

Conservation Needs
Management plans for state lands where this species resides should include habitat and population protection measures. Logging of habitat that supports Wehrle's salamander should be prevented.

Monitoring Needs
A long term monitoring program should be established. Monitoring should be focused on surveying to locate additional extant populations and determining the factors that best describe suitable habitat.

References Cited

Anderson, K. and H.G. Dowling. 1982. Geographic distribution: Hyla gratiosa (barking treefrog). SSAR Herp. Review 13(4):130.

Bishop, S.C. 1941. Salamanders of New York. New York State Museum Bulletin 324:1-365.

Boward, D.M., P.F. Kazyak, S.A. Stranko, M.K. Hurd, and T.P.Prochaska. 1999. From the Mountains to the Sea: The State of Maryland's Freshwater Streams. EPA 903-R-99-023. Maryland Department of Natural Resources, Monitoring and Non-tidal Assessment Division, Annapolis, Maryland.

Bruce , R.C. 1974. Larval development of the salamanders *Pseudotriton montanus* and *P. ruber*. The American Midland Naturalist 92:173-190.

Bury, R.B., C.K. Dodd, Jr., and G.M. Fellers. 1980. Conservation of the Amphibia of the United States: a review. U.S. Fish and Wildlife Service Res. Publ. 134:1-34.

Corn, P. S, R. B. Bury, E. J. Hyde. 2003. Conservation of stream amphibians in North America. In: Semlitsch R, editor. Amphibian conservation. Washington, DC: Smithsonian Institution Press. pp 24-36.

Cochran, P.A. and J.D. Lyons. 1985. Life history notes: Necturus maculosus.Juvenile ecology. SSAR Herpetological Review 16(2):53.

Collins, J.P. 1981. Distribution, habitats, and life history variation in the tiger salamander, ***Ambystoma tigrinum***, in east-central and southeast Arizona. Copeia 1981:666-675.

deMaynadier, P. G., and M. L. Hunter. 1999. Forest canopy closure and juvenile emigration by pool-breeding amphibians in Maine. Journal of Wildlife Management, 63:441-450.

Dundee, H.A. 1971. *Cryptobranchus* and *Cryptobranchus alleganiensis*. Catalogue of American Amphibians and Reptiles. pp. 101.1-101.4.

Espinoza, F.A., Jr., Deacon, J.E., and A. Simmin. 1970. An Economic and Biostatistical Analysis of the Bait Fish Industry in the Lower Colorado River. University Las Vegas Special Publication 1-87.

Franz, R., and H. Harris. 1965. Mass transformation and movement of larval long-tailed salamanders, *Eurycea longicauda longicauda* (Holbrook).

Gates, J.E., C. E. Hocutt, J.R. Stauffer Jr., G..J. Taylor. 1985. The distribution and status of *Cryptobranchus alleganiensis* in Maryland. Herpetological Review 16:17-18.

Given M.F. 1999. 1999, Frequency alteration of the advertisement calls in the carpenter frog, *Rana virgatipes*. Herpetologica, 55: 304-317.

Gore, J.A. 1983. The distribution of desmognathinae larvae (Amphibia: Plethodontidae) in coal surface impacted streams of the Cumberland Plateau, USA. Journal of Freshwater Ecology 2:13-23.

Hulse, A. C., C. J. McCoy, and E. Censky. 2001. Amphibians and Reptiles of Pennsylvania and the North east. Comstock Publishing Associates, Ithaca. 419 pp.

Keen, W.H., and L.P. Orr 1980. Reproductive cycle, growth, and maturation of northern female *Desmognathus ochrophaeus*. Journal of Herpetology 14:7-10.

Krzysik, A. J. 1979. Resource allocation, coexistence, and the niche structure of a streambank salamander community. Ecological Monographs 49:173-194.

Lowe, W.H., Nislow, K.H., Bolger, D.T., 2004. Stage-specific and interactive effects of sedimentation and trout on a headwater stream salamander. Ecol. Appl. 14, 164–172.

McCoy, C.J. 1982. Amphibians and reptiles in Pennsylvania: Checklist, bibliography, and atlas of distribution. Spec. Publ. Carnegie Mus. Natur. Hist. No. 6.

Mount, R. H. 1975. The Reptiles and Amphibians of Alabama. Auburn University Agricultural Experiment Station, Auburn. 347 pp.

Nickerson, M. A. and C.E. Mays. 1973. The hellbender: North America's "giant salamanders". Pub. Biol. Geol., Milw. Publ. Mus. 1:1-106.

Orr, L.P.1989. *Desmognathus ochrophaeus*. In: Salamanders of Ohio, R.A. Pfingsten and F.L. Downs, eds. Ohio Biological Survey Bulletin, New Series 7(2):181-189.

Orser, P. N., and D. J. Shure. 1972. Effects of urbanization on the salamander *Desmognathus fuscus fuscus*. Ecology 53:1148-1154.

Pauley, T.K. 1978. Moisture as a factor regulating habitat partitioning between two sympatric *Plethodon* species. Journal of Herpetology 12: 491-493.

Pearson, P. G. 1955. Population ecology of the spadefoot toad, *Scaphiopus h. holbrooki* Harlen. Ecol. Monogr. 25:233-267.

Petranka, J. 1998. Salamanders of the United States and Canada. Washington and London: Smithsonian Institution Press.

Rohr, J.R., Elskus, A.A., Shepherd, B.S., Crowley, P.H., McCarthy, T.M., Niedzwiecki, J.H., Sager, T., Sih, A., Palmer, B.D. 2004. Multiple stressors and salamanders: Effects of an herbicide, food limitation, and hydroperiod. Ecological Applications 14:1028-1040.

Resetarits, W.J. (1997) Differences in an ensemble of streamside salamanders (Plethodontidae) above and below a barrier to brook trout. Amphibia-Reptilia 18: 15-25.

Rothermel, B. B., and R. D. Semlitsch. 2002. An experimental investigation of landscape resistance of forest versus old-field habitats to emigrating juvenile amphibians. Conservation Biology 16:1324-1332.

Semlitsch, R.D., and J.B. Jensen. 2001. Resolving the distinction between buffer zones and core habitat. Missouri Chapter of the Society for Conservation Biology, Glade 4: 7-11.

Sih, A., L.B. Kats, and R.D. Moore. 1992. Effects of predatory sunfish on the density, drift, and refuge use of stream salamander larvae. Ecology 73:1418-1430.

Smith, S. and g.d. Grossman. 2003. Stream Microhabitat Use by Larval Southern Two-Lined Salamanders (*Eurycea cirrigera*) in the Georgia Piedmont. Copeia 3 (3) 531-543.

Stranko S.A., D.C. Forester, and J.V. Kilian. 2004. Discovery of the Jefferson salamander, *Ambystoma jeffersonianum* (Green), east of the Blue Ridge Mountains, in Frederick and Montgomery County, Maryland.The Maryland Naturalist 46(2):41-46.

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E. Young, A.S.L. Rodrigues, D.L. Fischman, and R.W. Waller. 2004. Status and trends in amphibian declines and extinctions worldwide. Science express www.sciencexpress.org.

Swanson, P.L. 1948. Notes on the amphibians and reptiles of Venango County, Pennsylvania. The American Midland Naturalist 40:362-371.

Taber, C.A., Wilkinson, R.F., Jr., Topping, M.S. 1975. Age and growth of hellbenders in the Niangua River, Missouri. Copeia 1975: 633-639.

Thompson, E.L., and J. E. Gates. 1982. Breeding pool segregation by the mole salamanders, *Ambystoma jeffersonianum* and *A. maculatum*, in a region of sympatry. Oikos 38 (3): 273-279.

Thompson, E. L., and G. J. Taylor. 1980. Distribution and breeding habitat selection of the Jefferson salamander, *Ambystoma jeffersonianum*, in Maryland. Journal of Herpetology 14: 113-120.

Willson, J. D., and M. E. Dorcas. 2003. The effects of habitat disturbance on stream dwelling salamander populations: implications for buffer zones and watershed management. Conservation Biology 17:763-771.

White, J.F., Jr. and A.W. White. 2002. Amphibians and reptiles of Delmarva.Tidewater Publishers, Centerville, Maryland. 248 pp.

Whiteman, H. H., R. D. Howard, and K. A. Whitten. 1995. Effects of pH on embryo tolerance and adult behavior in the tiger salamander, *Ambystoma tigrinum tigrinum*. Canadian Journal of Zoology 73: 1529-1537.

Wood, J.T., and F.E. Wood. 1955. Notes on the nests and nesting of the Carolina mountain dusky sala mander in Tennessee and Virginia. Journal of the Tennessee Academy of Science 30:36-39.

Appendix C. Benthic Macroinvertebrate Taxa List

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Hoplonemertea																		
Tetrastemmatidae																		
Prostoma		5.6	3.1	1.6	13.1	4.3	1.9	3.0	4.3	5.9	10.0	9.4	5.7	10.0	7.7	3.6	9.4	10.0
Tricladida																		
Planariidae																		
Cura			3.9	4.9	2.0	1.4		3.0	1.4	1.5	3.3	3.8	2.9	2.9	7.7	3.6	3.8	
Dugesia		5.6	18.8	14.6	6.1	1.4	8.5	3.0	11.5	16.2		3.8	20.0	8.6	7.7	5.5	11.3	10.0
Phagocata		1.9	3.9		4.0	2.1		3.0								3.6		
Tubificida																		
Naididae																		
Chaetogaster															2.6			
Tubificidae																		
Branchiura														1.4				
Limnodrilus	4.3		1.6	2.4	5.1	2.1	15.1	9.1	7.9	1.5	10.0	5.7	11.4	2.9			3.8	10.0
Spirosperma			4.7	1.6	8.1	6.4	4.7	3.0	0.7	4.4	3.3	3.8	11.4	1.4		3.6	1.9	
Rhynchobdellida																		
Glossiphoniidae																		
Alboglossiphonia													5.7					
Batracobdella														1.4				
Helobdella						0.7										1.8		
Placobdella									0.7							1.8	3.8	
Piscicolidae																		
Piscicola					2.0													
Bivalvia																		
Sphaeriidae																		
Musculium		0.9	1.6	0.8	5.1	5.0	2.8	9.1	0.7				5.7	17.1	25.6	12.7	5.7	10.0
Veneroida																		
Corbiculidae																		
Corbicula			1.6		2.0	1.4	4.7		1.4	2.9		1.9			7.7			
Sphaeriidae																		
Pisidium		0.9		5.7	5.1	1.4	0.9		0.7	4.4	6.7		2.9	20.0	5.1	5.5	1.9	
Sphaerium	8.5		7.0	0.8	2.0	4.3	6.6	9.1	2.2	5.9	3.3		17.1	5.7	5.1	7.3	9.4	40.0
Pharyngobdellida																		
Erpobdellidae																		
Mooreobdella						1.4												

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Mesogastropoda																		
Hydrobiidae																		
Amnicola													5.7				5.7	
Pleuroceridae																		
Goniobasis					1.0								5.7	2.9				
Leptoxis		0.9	3.9							2.9		1.9						
Viviparidae																		
Campeloma														1.4	5.1			
Viviparus							0.9											
Basommatophora																		
Ancylidae																		
Ferrissia		2.8	3.9	5.7	3.0	2.9	1.9		1.4	1.5		1.9	2.9	1.4		3.6	7.5	
Lymnaeidae																		
Pseudosuccinea			0.8	0.8		1.4	0.9	3.0	2.2	1.5	3.3			4.3	7.7	3.6		
Stagnicola	2.1	0.9	1.6	2.4	3.0	1.4	0.9	3.0	2.2	2.9	3.3	1.9	5.7	5.7	20.5	3.6	3.8	10.0
Physidae																		
Physella	2.1	0.9	9.4	13.0	18.2	7.1	8.5	36.4	8.6	4.4	16.7	3.8	37.1	47.1	35.9	23.6	18.9	10.0
Planorbidae																		
Gyraulus			0.8											1.4				
Helisoma			0.8			0.7				1.5			5.7					
Menetus			1.6	0.8	3.0	4.3	0.9		1.4		3.3		5.7	22.9	7.7	14.5	18.9	30.0
Planorbella				0.8	1.0								5.7	4.3	2.6	1.8		
Promenetus						1.4			1.4									
Amphipoda																		
Crangonyctidae																		
Crangonyx	4.3	7.4	15.6	18.7	36.4	25.7	12.3	9.1	12.2	14.7	16.7	1.9	5.7	4.3	23.1	56.4	60.4	60.0
Synurella			0.8	0.8	6.1	45.7	11.3	48.5	2.9	4.4	3.3		8.6	30.0	28.2	43.6	45.3	40.0
Gammaridae																		
Gammarus	6.4	20.4	19.5	4.9	8.1	9.3	29.2	33.3	2.9	2.9		20.8	14.3	27.1	28.2	29.1	5.7	20.0
Stygonectes		1.9	3.9	3.3		1.4	2.8	12.1	2.2	1.5		5.7	5.7	2.9	2.6	3.6		
Hyalellidae																		
Hyalella	10.6	0.9		2.4	2.0	6.4	5.7	6.1	3.6				5.7	5.7		1.8	1.9	
Isopoda																		
Asellidae																		
Caecidotea	21.3	22.2	25.0	8.9	17.2	57.9	26.4	54.5	9.4	7.4	33.3	1.9	25.7	61.4	76.9	76.4	66.0	100.0
Lirceus			9.4	5.7					0.7	1.5							1.9	

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Decapoda																		
Cambaridae																		
Cambarus	2.1	2.8	2.3	1.6	1.0									1.4				
Orconectes			1.6	1.6							3.3							
Procambarus						1.4					3.3			1.4	2.6	5.5	3.8	10.0
Palaemonidae																		
Palaemonetes					1.0	1.4											5.7	
Collembola																		
Isotomidae																		
Isotomurus		0.9	10.9	3.3	12.1	10.0	1.9	6.1	4.3	1.5		3.8	2.9	5.7	2.6	5.5	13.2	
Ephemeroptera																		
Ameletidae																		
Ameletus	14.9	41.7	35.9	28.5	11.1	7.9	14.2		14.4	23.5	13.3	32.1	14.3	1.4				
Baetidae																		
Acentrella	12.8	6.5	6.3	6.5	2.0	5.0	1.9	3.0	3.6	2.9	3.3	3.8	5.7	1.4	5.1	1.8		
Acerpenna	10.6	1.9	1.6	4.9	6.1	38.6	16.0	9.1	4.3	1.5		3.8	2.9	18.6	7.7	1.8		
Baetis	34.0	29.6	11.7	7.3	4.0				5.8	4.4	3.3	30.2	2.9					
Callibaetis				0.8		0.7	0.9						5.7	1.4	2.6			
Centroptilum	2.1		0.8	0.8	7.1	1.4	2.8		1.4	1.5			8.6					
Cloeon		0.9																
Diphetor	6.4	7.4	2.3	1.6	1.0		2.8											
Barbaetis		0.01																
Fallceon		2.8																
Procloeon							0.9			1.5								
Baetiscidae																		
Baetisca				0.8														
Caenidae																		
Caenis	6.4	2.8	9.4	1.6	6.1	1.4	1.9						31.4	7.1	12.8	1.8	11.3	
Ephemerellidae																		
Attenella						1.4												
Drunella	8.5	12.0	9.4	1.6			1.9		2.9	1.5		9.4	2.9					
Ephemerella	72.3	68.5	46.1	46.3	8.1	29.3	45.3	18.2	35.3	66.2	13.3	79.2	54.3	2.9	10.3			
Eurylophella	10.6	16.7	17.2	17.9	11.1	25.7	12.3		23.0	36.8	10.0	24.5	45.7	11.4	12.8	18.2	15.1	
Serratella	14.9	9.3	7.0	8.9	1.0		3.8		10.1	16.2		15.1	8.6					
Timpanoga						0.7												

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Ephemeridae																		
Ephemera	2.1	4.6	1.6	2.4					2.2			3.8	5.7					
Hexagenia														1.4				
Litobrancha	2.1																	
Pentagenia	2.1																	
Heptageniidae																		
Cinygmula	25.5	16.7	10.9	1.6														
Epeorus	40.4	60.2	25.8	12.2			1.9		5.0	17.6	3.3	34.0	17.1					
Heptagenia	4.3																	
Leucrocuta	2.1	7.4	3.1	2.4		0.7												
Nixe		0.9																
Stenacron	21.3	7.4	7.8	8.1	2.0	0.7	3.8		3.6	4.4		7.5	8.6	4.3	2.6		1.9	
Stenonema	42.6	31.5	18.8	29.3	24.2	25.7	34.9	9.1	31.7	38.2	16.7	56.6	40.0	22.9	25.6	29.1	7.5	
Isonychiidae																		
Isonychia	2.1	13.9	11.7	9.8	5.1		9.4		10.1	14.7	10.0	20.8	20.0					
Leptophlebiidae																		
Habrophlebia			0.8	0.8		3.6						9.4	2.9					20.0
Leptophlebia	4.3	0.9	3.9	2.4	3.0	22.1	13.2	6.1	2.2	2.9		5.7	11.4	10.0	10.3	7.3	18.9	
Paraleptophlebia	36.2	47.2	23.4	17.1	2.0	6.4	6.6	3.0	5.0	14.7	3.3	17.0	5.7		5.1			20.0
Metretopodidae																		
Siphloplecton						0.7												
Potamanthidae																		
Anthopotamus												1.9						
Siphlonuridae																		
Siphlonurus			1.6	0.8		4.3		3.0										
Odonata																		
Aeshnidae																		
Aeshna																1.8		
Anax															2.6			
Basiaeschna														0.03	0.05			
Boyeria	4.3	2.8			9.1	4.3	11.3	18.2	3.6	4.4	13.3	5.7	8.6	5.7	7.7	10.9	5.7	10.0
Nasiaeschna																	1.9	
Calopterygidae																		
Calopteryx		1.9		2.4	25.3	12.1	17.9	15.2	6.5	4.4		7.5	17.1	32.9	25.6	32.7	11.3	

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Coenagrionidae																		
Argia	2.1	2.8	0.8	1.6	9.1		2.8		3.6	1.5			11.4	10.0	5.1	3.6	5.7	
Enallagma			0.8	1.6	2.0	1.4			2.2		6.7	1.9	8.6		2.6	3.6	13.2	
Ischnura				0.8	1.0			3.0	0.7				5.7	7.1		1.8	1.9	
Cordulegastridae																		
Cordulegaster	2.1	0.9	1.6	1.6		7.1	4.7	24.2	2.9	1.5		1.9		2.9	2.6	3.6		
Corduliidae																		
Macromia				0.8	1.0		0.9				3.3							
Somatochlora					2.0	2.1			0.7					1.4		3.6	1.9	
Gomphidae																		
Arigomphus						0.02						0.02						
Dromogomphus							4.7											
Erpetogomphus									0.01									
Gomphus					1.0	2.9												
Hagenius					1.0					1.5								
Lanthus		1.9	0.8	1.6	1.0				0.7									
Progomphus														1.4				
Stylogomphus		2.8	0.8	0.8		1.4	3.8		0.7		6.7	5.7	2.9					
Lestidae																		
Lestes																	1.9	
Libellulidae																		
Erythemis														1.4				
Leucorrhinia	0.02																	
Libellula								3.0										
Pachydiplax							0.9						2.9					
Plathemis																	1.9	
Plecoptera																		
Capniidae																		
Allocapnia		6.5	6.3	8.1	2.0	10.0	5.7	9.1	7.9	7.4	3.3	5.7	5.7		2.6			
Capnia				0.01														
Paracapnia	4.3	6.5	5.5	8.1	3.0	3.6	1.9		0.7									
Chloroperlidae																		
Alloperla		5.6	3.1	1.6		0.7			0.7									
Haploperla						0.7	0.9											
Perlinella					0.01													
Sweltsa	4.3	36.1	18.8	9.8					2.2			9.4						

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Leuctridae																		
Leuctra	51.1	47.2	28.1	12.2	5.1	15.7	10.4	12.1	5.0	1.5	6.7	15.1	17.1		5.1			
Paraleuctra		1.9	0.8															
Nemouridae																		
Amphinemura	68.1	75.9	61.7	55.3	24.2	37.9	38.7	15.2	26.6	39.7	13.3	50.9	17.1	2.9	5.1	1.8		
Nemoura		0.9					0.9											
Ostrocerca	10.6	4.6	4.7	2.4		2.1	1.9	9.1	0.7	1.5			2.9	2.9				
Paranemoura	2.1		0.8															
Prostoia		6.5	8.6	18.7	10.1	12.1	21.7	12.1	23.0	35.3	10.0	41.5	17.1	7.1	7.7	1.8	9.4	
Shipsa						0.01												
Soyedina		1.9																
Peltoperlidae																		
Peltoperla	2.1	6.5	0.8	0.8					0.7									
Tallaperla	29.8	9.3	0.8	4.1					2.2	7.4		9.4						
Perlidae																		
Acroneuria	6.4	30.6	11.7	6.5	1.0		1.9		8.6	10.3	6.7	20.8	2.9					
Eccoptura			3.1	2.4	2.0	20.7	7.5	12.1	4.3	8.8	13.3	17.0	8.6					
Neoparla		0.01																
Paragnetina												5.7						
Perlesta				0.8		2.9	0.9			2.9							1.9	
Phasganophora	2.1								0.7									
Perlodidae																		
Clioperla	8.5	3.7	6.3	6.5	6.1	13.6	6.6	9.1	0.7					5.7	2.6			
Cultus	2.1					0.7	0.9		1.4		3.3							
Diploperla	8.5			0.8		1.4	1.9		0.7	1.5		1.9	2.9					
Helopicus												1.9						
Isoperla	40.4	22.2	19.5	8.9	6.1	22.1	12.3	9.1	0.7	2.9	3.3	15.1	2.9	12.9	12.8	14.5		
Malirekus		4.6							0.7									
Yugus		0.9																
Pteronarcyidae																		
Pteronarcys	19.1	31.5	4.7	4.1					1.4	4.4								
Taeniopterygidae																		
Oemopteryx	2.1	13.9	6.3	3.3	4.0	6.4	2.8		3.6	7.4	3.3	3.8	2.9					
Strophopteryx		1.9	3.1	10.6	3.0	8.6	6.6		7.2	16.2	10.0	11.3	8.6					
Taeniopteryx	2.1	4.6	2.3	1.6	1.0	2.1	0.9	6.1	3.6	11.8		7.5				1.8	5.7	

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Hemiptera																		
Belostomatidae																		
Belostoma					1.0				0.7				2.9	2.9	2.6		1.9	
Corixidae																		
Hesperocorixa						0.7	0.9											
Palmacorixa																	1.9	
Trichocorixa			1.6										2.9					
Gerridae																		
Aquarius						0.7												
Gerris								3.0						2.9				
Limnoporus							0.9										1.9	
Nepidae																		
Ranatra						0.7									2.6			
Noteridae																		
Hydrocanthus														1.4				
Notonectidae																		
Bueno									0.7									
Notonecta							0.9	3.0					2.9				1.9	
Veliidae																		
Microvelia			0.8		1.0	0.7	0.9	3.0		1.5				2.9	2.6	3.6	1.9	
Megaloptera																		
Corydalidae																		
Chauliodes					1.0	0.7		9.1			3.3		2.9	2.9		3.6	3.8	
Corydalus		1.9	0.8		3.0		0.9		1.4			3.8	2.9		2.6			
Nigronia	21.3	9.3	15.6	10.6	10.1	9.3	26.4	27.3	12.9	8.8	26.7	18.9	8.6	4.3	25.6	9.1		
Sialidae																		
Sialis	6.4	3.7	3.1	3.3	4.0	7.1	6.6	12.1	4.3	4.4	10.0	5.7	17.1	4.3		9.1	9.4	
Trichoptera																		
Brachycentridae																		
Brachycentrus	2.1								0.7									
Micrasema			0.8	0.8			0.9					3.8						
Calamoceratidae																		
Anisocentropus						0.7												
Heteroplectron						2.9	0.9	6.1	0.7						2.6	1.8		
Dipseudopsidae																		
Phylocentropus	2.1			0.8		2.9			0.7					1.4				

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Glossosomatidae																		
Agapetus													2.9					
Glossosoma		0.9	0.8	0.8	2.0		3.8		7.2	4.4		9.4	2.9					
Goeridae																		
Goera	4.3											5.7						
Helicopsychidae																		
Helicopsyche													2.9					
Hydropsychidae																		
Cheumatopsyche	34.0	31.5	24.2	37.4	47.5	30.7	54.7	12.1	54.7	57.4	46.7	69.8	51.4	44.3	17.9	32.7	7.5	30.0
Diplectrona	53.2	55.6	17.2	26.8	14.1	27.1	26.4	21.2	36.0	32.4	26.7	43.4	11.4	4.3	5.1	3.6		
Homoplectra			1.6						0.7			1.9						
Hydropsyche	46.8	49.1	16.4	26.0	37.4	15.7	32.1	6.1	46.0	61.8	40.0	67.9	17.1	12.9	2.6	5.5		
Parapsyche		1.9																
Potamyia		0.9																
Hydroptilidae																		
Hydroptila		0.9			1.0		0.9		1.4			1.9	2.9	1.4			1.9	
Leucotrichia										5.9								
Ochrotrichia			0.01															
Orthotrichia			0.8															
Oxyethira						1.4											5.7	
Lepidostomatidae																		
Lepidostoma	21.3	16.7	9.4	6.5		3.6	0.9		1.4	7.4		7.5	5.7		2.6	3.6		
Leptoceridae																		
Ceraclea														1.4				
Mystacides									0.7							1.8		
Nectopsyche															5.1			
Oecetis	2.1		0.8		2.0	1.4		3.0	0.7				5.7	7.1			3.8	
Triaenodes	2.1		1.6		1.0	5.0	1.9	9.1	2.2			1.9	2.9	2.9	5.1	1.8	13.2	
Limnephilidae																		
Hydatophylax		0.9		2.4		0.7	0.9	3.0	1.4		3.3	1.9			2.6			
Ironoquia	2.1	1.9	3.1	0.8	6.1	12.9	8.5	18.2		2.9	16.7		5.7	10.0	17.9	16.4	28.3	30.0
Limnephilus			1.6			0.7	0.9		0.7						2.6		3.8	
Platycentropus	2.1	0.9				0.7		3.0								3.6	3.8	10.0
Pycnopsyche	12.8	8.3	9.4	8.1	2.0	12.1	18.9	18.2	11.5	7.4	3.3	9.4	11.4	5.7	5.1	9.1	20.8	
Molannidae																		
Molanna	2.1			0.8	1.0		0.9		0.7	1.5						1.8		
Molannodes			2.3		1.0	1.4						1.9		2.9			3.8	

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Odontoceridae																		
Psilotreta				0.8		1.4	1.9	3.0	1.4	1.5		3.8	5.7	1.4	5.1			
Philopotamidae																		
Chimarra	10.6	12.0	14.8	21.1	10.1	5.0	11.3	3.0	15.1	17.6	3.3	24.5	14.3	1.4		1.8		
Dolophilodes	14.9	13.0	8.6	8.1	3.0	6.4	4.7	3.0	10.8	5.9		7.5			2.6			
Wormaldia	10.6	14.8	10.9	1.6		2.9	0.9		0.7		3.3	3.8	2.9	1.4				
Phryganeidae																		
Oligostomis		0.9																
Ptilostomis	2.1			0.8	2.0	7.1	9.4	27.3	2.2	2.9	3.3		5.7	5.7	5.1	3.6	3.8	20.0
Polycentropodidae																		
Neureclipsis			0.8									5.7	2.9					
Nyctiophylax	2.1	0.9		1.6		2.1			0.7		3.3		2.9	1.4	2.6			10.0
Polycentropus	10.6	8.3	5.5	5.7	6.1	7.9	9.4	12.1	5.8	10.3	3.3	11.3	11.4	17.1	7.7	5.5	20.8	
Psychomyiidae																		
Lype	6.4	0.9	1.6	8.9	2.0	6.4	15.1	21.2	5.0	7.4		5.7	5.7	14.3	15.4	12.7	1.9	10.0
Psychomyia	4.3			0.8			0.9		2.2			9.4						
Rhyacophilidae																		
Rhyacophila	42.6	37.0	24.2	24.4	9.1	8.6	10.4	3.0	20.1	19.1	13.3	26.4	8.6					
Sericostomatidae																		
Agarodes				0.8							3.3	1.9			2.6			
Uenoidae																		
Neophylax	48.9	49.1	28.1	35.8	18.2	15.0	36.8		38.1	32.4	6.7	45.3	14.3	4.3	7.7			
Lepidoptera																		
Pyralidae																		
Crambus							0.9											
Coleoptera																		
Dryopidae																		
Helichus			3.1	1.6	2.0	5.0	4.7	15.2	4.3	1.5		3.8	2.9	7.1	12.8			
Dytiscidae																		
Acilius									0.7					1.4				
Agabetes											3.3						1.9	
Agabus	2.1		0.8	7.3	2.0	1.4		6.1	1.4	2.9	10.0	1.9	2.9	1.4	15.4	3.6	11.3	
Copelatus					2.0	1.4							2.9	1.4		1.8	1.9	
Coptotomus									0.7									
Cybister			0.01					0.03										
Deronectes																	1.9	
Derovatellus														0.01				

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Helocombus								3.0				1.9			2.6			
Hydaticus																	1.9	
Hydroporus	2.1	0.9	3.1	4.1	8.1	12.9	7.5	33.3	4.3	2.9	20.0	1.9	20.0	27.1	12.8	20.0	39.6	20.0
Laccophilus			0.8		1.0	0.7												
Laccornis																3.6		
Matus														1.4		1.8		
Rhantus													5.7					
Uvarus							0.01											
Carabidae																		
Chlaenius						0.01												
Elmidae																		
Ancyronyx				1.6	3.0	0.7	7.5	12.1	2.9				11.4	17.1	15.4	1.8	3.8	
Dubiraphia	19.1	2.8	4.7	0.8	5.1	7.1	5.7		2.9	7.4		7.5	22.9	17.1	30.8		13.2	10.0
Macronychus		0.9	0.8	4.1	4.0	2.9	9.4	3.0	2.9			1.9	17.1	8.6	5.1	3.6		
Microcylloepus			0.8	1.6		0.7								1.4	2.6	1.8		
Optioservus	36.2	16.7	27.3	28.5	13.1	15.0	20.8	3.0	29.5	48.5	3.3	41.5	22.9	2.9				
Oulimnius	38.3	39.8	8.6	17.1	16.2	32.1	16.0	3.0	30.2	35.3		15.1	14.3		5.1			
Promoresia	10.6	0.9	1.6	2.4					0.7			3.8	8.6					
Stenelmis	6.4	4.6	26.6	30.1	27.3	23.6	17.0	6.1	13.7	16.2	13.3	17.0	25.7	25.7	17.9		1.9	10.0
Gyrinidae																		
Dineutus			0.8	0.8	2.0	8.6	7.5	3.0	0.7				11.4	7.1	2.6	9.1	3.8	
Gyrinus						2.1	1.9						5.7	5.7		3.6	1.9	
Haliplidae																		
Haliplus					1.0								2.9		2.6			
Peltodytes			0.8	1.6	2.0	1.4					3.3		8.6	10.0		5.5	11.3	20.0
Helophoridae																		
Helophorus				0.8							3.3	1.9						
Hydrophilidae																		
Berosus				0.8		0.7					3.3		2.9				1.9	
Cymbiodyta												1.9	2.9				1.9	
Enochrus			0.8									3.8	2.9	1.4		9.1		
Helochares						0.7												
Hydrobius		0.9	0.8			0.7	2.8	9.1	0.7			1.9	2.9	7.1	7.7	3.6		
Hydrochara														1.4	2.6		1.9	
Hydrochus					2.0	0.7	0.9						2.9	1.4	2.6	1.8		
Hydrophilus				0.01			0.01											
Sperchopsis				0.8														

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Tropisternus				1.6		0.7			0.7		3.3		2.9	2.9		3.6		
Psephenidae																		
Ectopria	6.4	4.6	3.9	4.1					0.7	2.9		5.7	2.9					
Psephenus		11.1	13.3	15.4	6.1	8.6	1.9		6.5	8.8	13.3	15.1	11.4	1.4	2.6			
Ptilodactylidae																		
Anchytarsus	2.1	0.9	0.8	5.7	3.0	10.7	14.2	21.2	13.7	14.7	13.3	17.0	5.7		7.7			
Scirtidae																		
Cyphon						0.7	0.9	3.0										
Diptera																		
Athericidae																		
Atherix	2.1	0.9	2.3	1.6									2.9					
Blephariceridae																		
Blephariceraa	4.3	1.9	0.8															
Ceratopogonidae																		
Atrichopogon																		10.0
Alluaudomyia																	0.02	
Bezzia		1.9	1.6	2.4	2.0	2.9	3.8	3.0				5.7	5.7	10.0		1.8	3.8	10.0
Ceratopogon	8.5	7.4	11.7	4.9	4.0	12.9	5.7	21.2	8.6	2.9	6.7	7.5	2.9	5.7	5.1	1.8	3.8	
Culicoides	2.1		1.6	1.6	3.0	0.7		9.1	2.2	2.9			2.9	2.9	5.1	1.8	1.9	20.0
Dasyhelea		0.9	1.6															
Helius							0.9				3.3							
Mallochohelea																1.8		
Probezzia	21.3	8.3	10.2	10.6	4.0	16.4	2.8	6.1	6.5	13.2		15.1	5.7	4.3			1.9	
Sphaeromias														1.4			1.9	
Stilobezzia					1.0		1.9											
Chaoboridae																		
Chaoborus		0.9				0.7	0.9		0.7		3.3	1.9		1.4				
Chironomidae																		
Chironomini																		
Chironomini	6.4	2.8	3.1	5.7	2.0	5.0	10.4	12.1	4.3	1.5	3.3	3.8	8.6	12.9	5.1	20.0		20.0
Chironomus			1.6	4.1	5.1	2.1	2.8	9.1	5.0			1.9		4.3	20.5	14.5	3.8	20.0
Cladopelma	2.1																	
Cryptochironomus	8.5	2.8	3.9	8.9	6.1	3.6	2.8	6.1	5.0	1.5	3.3		8.6	10.0	10.3	10.9	1.9	10.0
Cryptotendipes																	1.9	
Dicrotendipes	4.3	2.8	4.7	1.6	9.1	5.7	5.7	3.0	7.2	8.8	6.7	1.9	17.1	25.7	23.1	5.5	5.7	10.0
Endochironomus	2.1	1.9		1.6	1.0	0.7	4.7		2.2		3.3		2.9	5.7		3.6	3.8	10.0
Glyptotendipes					1.0		3.8		0.7		3.3			2.9				10.0

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Kiefferulus							0.9				3.3			4.3	2.6	3.6	1.9	
Microtendipes	14.9	16.7	14.8	16.3	13.1	17.9	26.4	15.2	15.1	10.3	3.3	15.1	20.0	14.3	17.9	20.0	5.7	10.0
Parachironomus			0.8		2.0	1.4	0.9							5.7	2.6	5.5	3.8	
Paracladopelma					1.0	0.7	0.9		0.7	1.5						1.8	1.9	
Paralauterborniella	2.1						0.9							4.3				
Paratendipes			1.6		4.0	2.9	4.7	3.0	0.7		3.3		5.7	14.3	15.4	5.5	1.9	
Phaenopsectra			0.8	4.1	15.2	7.9	5.7	9.1	6.5	2.9	3.3		28.6	22.9	12.8	10.9	18.9	20.0
Polypedilum	19.1	25.9	22.7	30.1	39.4	40.0	54.7	30.3	24.5	26.5	16.7	32.1	48.6	75.7	66.7	67.3	35.8	20.0
Robackia								6.1										
Saetheria					1.0		0.9											
Stenochironomus	2.1		0.8	1.6	4.0	5.7	6.6	9.1	0.7		3.3		5.7	8.6		1.8	3.8	
Stictochironomus	2.1		0.8	3.3	5.1		3.8		2.2		3.3	1.9	5.7	5.7	2.6	5.5	5.7	
Tribelos		0.9		0.8	10.1	5.7	6.6	9.1	2.9		3.3		5.7	12.9	10.3	25.5	26.4	30.0
Xenochironomus					1.0													
Coelotanypodini																		
Alotanypus									0.7					1.4				
Clinotanypus	4.3		0.8	1.6	1.0	2.9	0.9		0.7	2.9				22.9	2.6	5.5	18.9	
Diamesini																		
Diamesa	19.1	37.0	28.1	52.8	27.3	2.9	14.2		28.1	30.9	46.7	47.2	31.4					
Diamesinae	2.1	10.2	9.4	17.1	8.1				5.0	4.4		11.3		1.4				
Pagastia			0.8	0.8					0.7	1.5		5.7						
Potthastia		1.9	3.1	3.3	5.1	3.6	7.5		0.7	1.5		1.9	2.9	5.7	15.4	9.1	3.8	
Sympotthastia		7.4	3.9	31.7	9.1	3.6	11.3	3.0	30.9	48.5	36.7	18.9	11.4	1.4				10.0
Macropelopiini																		
Apsectrotanypus	4.3			0.8		7.1	1.9	3.0	2.9	2.9		1.9		14.3		16.4	5.7	
Brundiniella				0.8			0.9					1.9						
Macropelopia				0.8														
Psectrotanypus			0.8															
Natarsiini																		
Natarsia	2.1		3.9	7.3	2.0	3.6	3.8	18.2	5.0	5.9	13.3	5.7	2.9	1.4		3.6	3.8	
Orthocladiinae																		
Brillia	10.6	12.0	0.8	14.6	22.2	5.7	22.6		20.9	14.7	10.0	15.1	5.7	2.9		10.9		
Cardiocladius	2.1	0.9		1.6	4.0				5.0		3.3	1.9						
Chaetocladius	2.1	5.6	6.3	7.3	8.1	2.1	6.6	15.2	5.8	10.3	3.3	3.8	17.1	18.6	5.1	3.6	5.7	
Corynoneura	14.9	7.4	21.9	25.2	18.2	25.0	23.6	15.2	23.7	32.4	6.7	22.6	22.9	21.4	28.2	20.0	30.2	10.0
Cricotopus	2.1	2.8	5.5	17.9	22.2	15.0	22.6	6.1	27.3	20.6	10.0	11.3	14.3	21.4	5.1	12.7		10.0
Diplocladius	6.4	4.6	4.7	3.3	9.1	18.6	8.5	36.4	2.9	2.9	6.7		8.6	18.6	20.5	7.3	11.3	30.0

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Eukiefferiella	34.0	28.7	29.7	35.0	22.2	31.4	25.5	6.1	38.1	42.6	30.0	34.0	17.1	8.6	2.6	1.8	1.9	
Georthocladius						0.7												
Heleniella	4.3	6.5	3.9	3.3		2.1	1.9		2.9	5.9				1.4				
Heterotrissocladius	14.9	2.8	12.5	5.7	5.1	10.7	5.7	18.2	2.9	7.4			5.7	2.9		1.8	5.7	10.0
Hydrobaenus		2.8	9.4	25.2	38.4	15.0	14.2	24.2	7.9	16.2	36.7	17.0	31.4	20.0	38.5	29.1	37.7	20.0
Limnophyes	6.4	1.9	3.1	4.1	9.1	1.4	1.9	15.2	7.2	1.5	3.3	3.8	5.7	4.3	2.6	5.5	15.1	10.0
Lopescladius						0.7												
Mesocricotopus			0.8														1.9	
Mesosmittia								3.0	0.7							1.8	1.9	
Metriocnemus														1.4				
Nanocladius	10.6	4.6	2.3	4.9	6.1	12.1	10.4	9.1	7.9	11.8		9.4	22.9	28.6	15.4	20.0	9.4	
Orthocladiinae	51.1	29.6	27.3	40.7	55.6	20.7	27.4	30.3	37.4	30.9	46.7	26.4	40.0	30.0	38.5	23.6	37.7	30.0
Orthocladiinae type A				11.4	11.1	5.7	25.5	3.0	7.9	1.5	10.0	1.9	8.6		2.6			
Orthocladiinae type B																	1.9	
Orthocladius	17.0	19.4	32.0	47.2	50.5	22.9	39.6	24.2	42.4	51.5	76.7	56.6	37.1	61.4	46.2	32.7	39.6	10.0
Parachaetocladius	8.5	11.1	5.5	1.6	2.0	2.9	5.7	12.1	2.9	1.5							1.9	
Parakiefferiella			3.9	10.6	3.0	1.4	5.7		2.2	4.4		1.9	8.6	2.9	2.6	3.6	7.5	
Parametriocnemus	74.5	76.9	60.9	78.9	47.5	51.4	75.5	63.6	62.6	61.8	53.3	67.9	48.6	50.0	25.6	10.9	5.7	20.0
Paraphaenocladius		11.1	8.6	13.0	7.1	6.4	8.5	36.4	7.2	14.7	16.7	11.3	8.6	18.6	25.6	1.8	7.5	
Parasmittia						0.7										1.8		
Paratrichocladius						0.01			0.01							0.02		
Platysmittia		0.9	1.6		1.0				1.4			1.9						
Psectrocladius					2.0								5.7		2.6	1.8	7.5	
Pseudorthocladius		1.9	2.3	3.3	3.0	1.4	1.9	18.2	1.4	2.9	6.7	1.9	5.7	8.6	7.7	1.8	3.8	
Pseudosmittia														1.4				
Psilometriocnemus	2.1	0.9		0.8														
Rheocricotopus	12.8	13.9	10.9	15.4	14.1	16.4	24.5	3.0	7.2	4.4	13.3	7.5	37.1	41.4	43.6	27.3	7.5	
Rheosmittia	2.1	0.9					0.9									1.8		
Smittia			0.8		3.0		0.9	9.1	1.4	1.5	3.3					3.6	1.9	
Stilocladius			1.6	0.8		0.7	5.7	3.0	6.5	7.4	3.3	1.9	2.9		2.6		1.9	
Symposiocladius	10.6	0.9	2.3	4.1	4.0	5.0	19.8	12.1	5.8	2.9	6.7		14.3	15.7		3.6		
Synorthocladius							1.9					3.8						
Thienemanniella	21.3	1.9	19.5	35.0	11.1	17.1	33.0	9.1	28.1	19.1	10.0	24.5	14.3	10.0	28.2	12.7	1.9	
Thienemannimyia Group	36.2	19.4	17.2	30.1	23.2	20.0	34.9	33.3	27.3	10.3	46.7	32.1	34.3	41.4	25.6	38.2	11.3	20.0
Tvetenia	38.3	26.9	19.5	30.1	32.3	10.7	33.0	18.2	25.2	44.1	23.3	30.2	22.9	11.4	7.7	18.2	34.0	
Unniella		0.9	0.8			7.9						1.9				3.6	11.3	
Xylotopus						5.0	3.8	6.1			3.3		11.4	5.7		1.8		

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Zalutschia								3.0			3.3				2.6	1.8	26.4	
Pentaneurini																		
Ablabesmyia		0.9	3.1		19.2	15.7	15.1	3.0	2.9		10.0		14.3	30.0	15.4	25.5	20.8	
Conchapelopia	12.8	8.3	16.4	23.6	13.1	23.6	35.8	9.1	30.2	41.2	6.7	24.5	34.3	42.9	25.6	23.6	28.3	20.0
Guttipelopia							0.9											
Krenopelopia			3.1	1.6	2.0	1.4			1.4					2.9				
Labrundinia						2.9	2.8						2.9	10.0	2.6	7.3	5.7	
Larsia				0.8	1.0	3.6	1.9			1.5						1.8	7.5	
Meropelopia	2.1	1.9	10.2	9.8	23.2	19.3	13.2	15.2	15.8	8.8		7.5	17.1	15.7	7.7	3.6	13.2	
Nilotanypus			0.8															
Paramerina			0.8	0.8		1.4				1.5			11.4	5.7	12.8	9.1	9.4	
Pentaneura			0.02			0.01	0.01					0.01						
Rheopelopia	0.02												0.03					
Thienemannimyia	2.1	0.9	0.8	0.8	1.0		0.9		0.7			1.9		1.4	2.6			
Trissopelopia	17.0	3.7	3.1	7.3	11.1	19.3	13.2	15.2	17.3	20.6	10.0	15.1	14.3	8.6	10.3	9.1		
Zavrelimyia	6.4	3.7	14.1	14.6	20.2	27.1	23.6	54.5	22.3	8.8	16.7	9.4	31.4	25.7	23.1	29.1	22.6	20.0
Procladiini																		
Procladius			2.3	1.6	1.0	5.7	0.9	3.0		1.5	3.3		8.6	14.3		5.5	13.2	10.0
Prodiamesinae																		
Odontomesa							0.9	12.1										
Prodiamesa	2.1	0.9	1.6	0.8	3.0		1.9	12.1	0.7	2.9		1.9		1.4		1.8		
Pseudochironomini																		
Pseudochironomus			0.8							2.9								
Tanypodinae																		
Tanypodinae	19.1	10.2	13.3	17.9	18.2	21.4	16.0	27.3	15.1	13.2	13.3	13.2	40.0	35.7	20.5	18.2	17.0	20.0
Tanypodini																		
Tanypus		0.9					0.9							4.3			1.9	
Tanytarsini																		
Cladotanytarsus		0.9	0.8	1.6		0.7	0.9			2.9				2.9		1.8	1.9	
Constempellina				1.6														
Micropsectra	46.8	49.1	41.4	35.8	19.2	20.7	27.4	21.2	24.5	30.9	16.7	18.9	40.0	22.9	15.4	21.8		
Paratanytarsus	2.1	1.9	3.1	3.3	18.2	8.6	10.4		10.1	4.4	6.7	1.9	20.0	25.7	7.7	10.9	15.1	10.0
Rheotanytarsus	10.6	2.8	9.4	22.0	25.3	25.0	42.5	15.2	22.3	26.5	30.0	15.1	31.4	28.6	10.3	23.6	11.3	
Stempellina	4.3	0.9	1.6	1.6		2.1			0.7			1.9						
Stempellinella	8.5	9.3	7.0	14.6	4.0	8.6	3.8	6.1	2.9	8.8		3.8	8.6	14.3	2.6	10.9	1.9	
Sublettea	2.1		1.6	0.8	1.0		0.9		1.4	1.5		1.9						
Tanytarsus	10.6	13.0	18.8	26.8	23.2	34.3	24.5	6.1	13.7	33.8	10.0	20.8	25.7	40.0	43.6	29.1	32.1	10.0

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Zavrelia									0.7									
Culicidae																		
Aedes						0.7							2.9	4.3		1.8	3.8	10.0
Culex								3.0										
Dixidae																		
Dixa		0.9	2.3	1.6		1.4	5.7		2.9	2.9		1.9						
Dixella						0.7	1.9											
Empididae																		
Chelifera	19.1	13.0	7.0	4.9	1.0	0.7	9.4		8.6	4.4	3.3	3.8	11.4			5.5		
Clinocera	2.1	2.8	7.0	17.1	10.1	1.4	14.2		17.3	14.7	20.0	22.6	22.9			1.8		
Hemerodromia	4.3	5.6	4.7	9.8	23.2	14.3	20.8	6.1	12.9	14.7	10.0	13.2		2.9	7.7	10.9	5.7	
Muscidae																		
Limnophora									0.7									
Psychodidae																		
Pericoma			0.8	4.1						1.5				1.4				
Psychoda	2.1				1.0				1.4						2.6			
Ptychopteridae																		
Bittacomorpha	2.1			0.8		1.4	2.8	6.1	2.2					1.4		1.8	1.9	
Ptychoptera				0.8		0.7		3.0		1.5								
Simuliidae																		
Cnephia	2.1		2.3	2.4					0.7				2.9	1.4	10.3	1.8	7.5	10.0
Greniera																	1.9	
Prosimulium	68.1	61.1	53.9	57.7	19.2	52.1	43.4	12.1	43.9	58.8	26.7	64.2	45.7	28.6	41.0	1.8	3.8	10.0
Simulium	14.9	10.2	25.0	40.7	20.2	29.3	23.6	6.1	27.3	29.4	6.7	15.1	28.6	25.7	35.9	20.0	24.5	20.0
Stegopterna	25.5	8.3	27.3	22.0	20.2	41.4	30.2	48.5	15.8	16.2	40.0	18.9	11.4	22.9	38.5	14.5	39.6	60.0
Stratiomyidae																		
Stratiomys								3.0					2.9	2.9				
Syrphidae																		
Chrysogaster					1.0	0.7		3.0										
Tabanidae																		
Chrysops	6.4	1.9	2.3	7.3	3.0	12.9	10.4	18.2	10.1	2.9	3.3	1.9	5.7	5.7	5.1	9.1	9.4	30.0
Tabanus				1.6	1.0	2.9			0.7		6.7			2.9	2.6		1.9	
Tanyderidae																		
Protoplasa										1.5								
Tipulidae																		
Antocha	25.5	15.7	10.2	13.0	15.2	1.4	17.0	3.0	35.3	41.2	26.7	52.8	8.6					
Dicranota	44.7	21.3	6.3	15.4	4.0	5.0	9.4	15.2	9.4	10.3	3.3	9.4	14.3	2.9		5.5		

Appendix C

	Youghiogheny	North Branch Potomac	Upper Potomac	Middle Potomac	Potomac Washington Metro	Lower Potomac	Patuxent	West Chesapeake	Patapsco	Gunpowder	Bush	Susquehanna	Elk	Chester	Choptank	Nanticoke/Wicomico	Pocomoke	Ocean Coastal
Erioptera		2.8				0.7	0.9											
Hexatoma	31.9	41.7	15.6	19.5	6.1	21.4	16.0	21.2	8.6	5.9	3.3	17.0	11.4	4.3	10.3	1.8	3.8	
Limnophila							0.9		0.7									
Limonia			1.6	1.6	1.0			3.0	3.6		6.7					1.8		
Liogma								3.0										
Molophilus	6.4	5.6	1.6	0.8		0.7	0.9						2.9					
Ormosia	6.4	2.8	3.1	2.4	3.0	3.6	0.9	21.2	5.0	2.9	3.3		5.7	4.3	2.6		3.8	
Pedicia	2.1													1.4				
Pseudolimnophila	19.1	10.2	8.6	15.4	9.1	15.7	12.3	12.1	9.4	14.7	6.7	20.8	5.7	18.6	10.3	16.4	11.3	10.0
Rhabdomastix							0.9											
Tipula	14.9	21.3	23.4	26.0	39.4	31.4	46.2	57.6	38.8	29.4	36.7	22.6	22.9	11.4	15.4	5.5	3.8	

Appendix D. Threats to Maryland Watersheds

Watershed: **Aberdeen Proving Ground** 02130705

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	4	2	5	5	1	4	3
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Anacostia River** 02140205

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	5	3	3	4	3	2	4
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	5	2	3	3	2	2	4
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	4	3	3	4	2	2	3
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Antietam Creek** 02140502

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Assawoman Bay** 02130102

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Atkisson Reservoir** 02130703

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Back Creek** 02130604

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Back River** 02130901

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	5	3	3	4	2	2	4
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Baltimore Harbor** 02130903

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	2	3	2	3	3	1	1
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	5	3	3	4	3	2	4
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	5	3	3	4	2	2	4
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Big Annemessex River** 02130207

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Big Elk Creek** 02130606

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Bird River** 02130803

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Bodkin Creek** 02130902

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Bohemia River** 02130602

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Breton Bay** 02140104

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	1	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Brighton Dam** 02131108

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Broad Creek** 02120205

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Bush River** 02130701

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	2	3	2	3	3	1	1
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Bynum Run** 02130704

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Cabin John Creek** 02140207

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	2	3	2	3	3	1	1
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	4	3	3	4	2	2	3
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Casselman River** 05020204

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	4	1	5	5	1	4	3
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	1	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Catoctin Creek** 02140305

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	5	3	3	4	3	2	4
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Chincoteague Bay** 02130106

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	5	2	3	3	2	2	4
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	3	3	3	4	2	2	2
Non-natives		Invasive plants (riparian)	1	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	1	2	2	3	2	1	1

Watershed: **Christina River** 02130607

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	0	3	3	4	2	0	0
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Conewago Creek** 02050301

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Conococheague Creek** 02140504

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Conowingo Dam Susq R** 02120204

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Corsica River** 02130507

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	3	3	3	4	2	2	2
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Deep Creek Lake** 05020203

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	4	1	5	5	1	4	3
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	1	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Deer Creek** 02120202

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Dividing Creek** 02130204

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Double Pipe Creek** 02140304

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Eastern Bay** 02130501

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Evitts Creek** 02141002

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Fifteen Mile Creek** 02140511

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	5	3	3	4	3	2	4
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Fishing Bay** 02130307

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	1	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Furnace Bay** 02130609

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Georges Creek** 02141004

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	4	1	5	5	1	4	3
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Gilbert Swamp** 02140107

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Gunpowder River** 02130801

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Gwynns Falls** 02130905

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	3	3	2	3	3	1	2
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	5	3	3	4	2	2	4
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Honga River** 02130401

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Isle of Wight Bay** 02130103

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	5	2	3	3	2	2	4
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	1	2	2	3	2	1	1

Watershed: **Jones Falls** 02130904

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	2	3	2	3	3	1	1
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	5	3	3	4	2	2	4
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Kent Island Bay** 02130511

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Kent Narrows** 02130504

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **L Susquehanna River** 02120201

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	3	3	2	3	3	1	2
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Langford Creek** 02130506

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Liberty Reservoir** 02130907

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	5	3	3	4	3	2	4
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Licking Creek** 02140506

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Little Choptank** 02130402

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	5	2	3	3	2	2	4
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	5	3	3	4	2	2	4
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Little Conococheague** 02140505

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Little Elk Creek** 02130605

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Little Gunpowder Falls** 02130804

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Little Patuxent River** 02131105

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	3	3	2	3	3	1	2
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	3	2	2	3	3	1	2
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Little Tonoloway Creek** 02140509

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Little Youghiogheny R** 05020202

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Loch Raven Reservoir** 02130805

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Lower Chester River** 02130505

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	3	2	2	3	3	1	2
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	3	3	3	4	2	2	2
Non-natives		Invasive plants (riparian)	5	3	2	3	2	2	3
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Lower Choptank** 02130403

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Lower Elk River** 02130601

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Lower Gunpowder Falls** 02130802

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Lower Monocacy River** 02140302

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Lower Pocomoke River** 02130202

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	4	2	5	5	1	4	3
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Lower Wicomico River** 02130301

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	3	2	2	3	3	1	2
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Lower Winters Run** 02130702

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	3	2	2	3	3	1	2
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Magothy River** 02131001

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	2	3	2	3	3	1	1
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Manokin River** 02130208

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	1	2	2	3	2	1	1

Watershed: **Marsh Run** 02140503

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Marshyhope Creek** 02130306

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Mattawoman Creek** 02140111

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	3	3	3	4	2	2	2
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Middle Chester River** 02130509

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Middle Patuxent River** 02131106

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Middle River - Browns** 02130807

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	4	3	3	4	2	2	3
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Miles River** 02130502

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	5	3	3	4	2	2	4
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	1	2	2	3	2	1	1

Watershed: **Monie Bay** 02130302

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Nanjemoy Creek** 02140110

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Nanticoke River** 02130305

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Nassawango Creek** 02130205

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Newport Bay** 02130105

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	5	2	3	3	2	2	4
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Northeast River** 02130608

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Octoraro Creek** 02120203

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Oxon Creek** 02140204

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	5	3	3	4	2	2	4
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	1	2	2	3	2	1	1

Watershed: **Patapsco River L N Br** 02130906

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	2	3	2	3	3	1	1
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Patuxent River lower** 02131101

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Patuxent River middle** 02131102

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Patuxent River upper** 02131104

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Piscataway Creek** 02140203

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Pocomoke Sound** 02130201

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Port Tobacco River** 02140109

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Potomac River AL Cnty** 02140508

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Potomac River FR Cnty** 02140301

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Potomac River L N Branch** 02141001

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	1	1	5	5	1	2	1
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Potomac River L tidal** 02140101

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	4	2	5	5	1	4	3
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Potomac River M tidal** 02140102

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	4	2	5	5	1	4	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	3	3	3	4	2	2	2
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Potomac River MO Cnty** 02140202

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	3	3	2	3	3	1	2
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Potomac River U N Branch** 02141005

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	4	1	5	5	1	4	3
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	1	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Potomac River U tidal** 02140201

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Potomac River WA Cnty** 02140501

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	3	3	2	3	3	1	2
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Prettyboy Reservoir** 02130806

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Rock Creek** 02140206

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	2	3	2	3	3	1	1
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	4	3	3	4	2	2	3
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Rocky Gorge Dam** 02131107

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	3	3	2	3	3	1	2
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **S Branch Patapsco** 02130908

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Sassafras River** 02130610

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Savage River** 02141006

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	1	1	5	5	1	2	1
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	5	3	3	4	3	2	4
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Seneca Creek** 02140208

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Severn River** 02131002

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Sideling Hill Creek** 02140510

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	5	2	2	3	2	2	3

Watershed: **Sinepuxent Bay** 02130104

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	5	3	3	4	2	2	4
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **South River** 02131003

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	3	2	2	3	3	1	2
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Southeast Creek** 02130508

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **St. Clements Bay** 02140105

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **St. Mary's River** 02140103

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	4	3	4	2	3	1	4
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Stillpond-Fairlee** 02130611

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Swan Creek** 02130706

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	2	3	2	3	3	1	1
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	3	2	2	3	3	1	2
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Tangier Sound** 02130206

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	2	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Tonoloway Creek** 02140507

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	3	4	4	5	1	4	2
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	0	2	2	3	2	0	0

Watershed: **Town Creek** 02140512

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	2	3	2	3	4	1	2
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	4	3	4	2	3	1	4
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Transquaking River** 02130308

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Tuckahoe Creek** 02130405

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	5	2	3	3	2	2	4
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	1	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Upper Chester River** 02130510

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	3	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	3	2	3	3	2	1	2
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	3	3	3	4	2	2	2
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Upper Choptank** 02130404

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	4	2	2	2	3	1	3
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Upper Elk River** 02130603

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	3	3	3	4	3	1	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Upper Monocacy River** 02140303

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	3	3	2	3	3	1	2
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	4	3	3	4	3	2	3
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Upper Pocomoke River** 02130203

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	5	3	2	3	3	2	4
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	5	2	2	3	3	2	4
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	5	2	3	3	2	2	4
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	4	3	3	4	2	2	3
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	5	3	3	4	2	2	4
Non-natives		Invasive plants (riparian)	2	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **West Chesapeake Bay** 02131005

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	4	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	2	3	3	4	3	1	2
Habitat Alteration		Surface water withdrawal	5	2	2	2	3	1	4
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **West River** 02131004

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	3	3	4	2	3	1	3
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	0	2	3	3	2	0	0
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	4	2	3	3	2	2	3
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Western Branch** 02131103

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	1	2	4	4	2	1	1
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	4	3	2	3	2	2	2
Habitat Alteration		Ground Water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Migration Barriers	5	2	3	3	2	2	4
Habitat Alteration		Runoff/ baseflow/ down cutting	3	3	3	4	2	2	2
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Wicomico Creek** 02130303

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	0	3	2	3	3	0	0
Chemical	Non-point Source	Excess Phosphorus	0	3	2	3	4	0	0
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	5	2	5	5	1	5	4
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	0	3	2	3	2	0	0
Non-natives		Non-native species (aquatic)	1	2	2	3	2	1	1

Watershed: **Wicomico River** 02140106

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	4	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	0	2	3	3	3	0	0
Chemical	Point Source	Pathogens/ Endocrine disruptors	1	3	4	2	3	1	1
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	2	2	5	5	1	3	2
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	5	3	3	4	3	2	4
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	3	3	3	4	2	2	2
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Wicomico River Head** 02130304

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	3	2	4	4	2	2	3
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	1	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	5	2	3	3	3	2	4
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	4	4	4	5	1	4	3
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	3	3	2	3	2	1	2
Habitat Alteration		Ground Water withdrawal	3	2	2	2	3	1	2
Habitat Alteration		Migration Barriers	3	2	3	3	2	1	2
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	4	3	2	3	2	2	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Wills Creek** 02141003

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	2	2	4	4	2	1	2
Chemical	Non-point Source	Acid Mine Drainage	2	1	5	5	1	2	2
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	3	3	3	4	3	1	3
Chemical	Point Source	Agricultural Pesticides	0	2	2	3	3	0	0
Chemical	Point Source	Dissolved Oxygen	0	3	4	2	3	0	0
Chemical	Point Source	Industrial (NPDES)	3	2	3	3	3	1	3
Chemical	Point Source	Pathogens/ Endocrine disruptors	3	3	4	2	3	1	3
Future Changes		Land Conversion	1	4	4	5	1	2	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	4	2	3	3	2	2	3
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	4	2	2	3	2	2	2

Watershed: **Wye River** 02130503

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	0	2	4	4	2	0	0
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	4	3	2	3	3	1	3
Chemical	Non-point Source	Excess Phosphorus	5	3	2	3	4	1	4
Chemical	Non-point Source	Mercury Deposition	2	3	2	4	2	1	1
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	4	2	2	3	3	1	3
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	3	2	5	5	1	3	3
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	5	3	2	3	2	2	3
Habitat Alteration		Ground Water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	4	3	3	4	3	2	3
Habitat Alteration		Surface water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Wetland Loss	4	3	3	4	2	2	3
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	2	2	2	3	2	1	1

Watershed: **Youghiogheny River** 05020201

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	1	1	5	5	1	2	1
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	1	3	2	3	4	0	1
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	2	3	3	4	3	1	2
Chemical	Point Source	Agricultural Pesticides	2	2	2	3	3	1	1
Chemical	Point Source	Dissolved Oxygen	1	3	4	2	3	1	1
Chemical	Point Source	Industrial (NPDES)	2	2	3	3	3	1	2
Chemical	Point Source	Pathogens/ Endocrine disruptors	2	3	4	2	3	1	2
Future Changes		Land Conversion	2	4	4	5	1	3	1
Future Changes		Sea Level Rise	0	2	5	5	1	1	0
Habitat Alteration		Channelization	1	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	1	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	2	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	1	3	3	4	3	1	1
Habitat Alteration		Surface water withdrawal	2	2	2	2	3	1	1
Habitat Alteration		Wetland Loss	1	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	1	3	2	3	2	1	1
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Watershed: **Zekiah Swamp** 02140108

Category	Subcategory	Name	Extent	Trend	Severity	Persistence	Reversibility	Prevention	Restoration
Chemical	Non-point Source	Acid deposition/ Low pH	5	2	4	4	2	2	4
Chemical	Non-point Source	Acid Mine Drainage	0	1	5	5	1	1	0
Chemical	Non-point Source	Excess Nitrates	1	3	2	3	3	0	1
Chemical	Non-point Source	Excess Phosphorus	4	3	2	3	4	1	3
Chemical	Non-point Source	Mercury Deposition	4	3	2	4	2	2	2
Chemical	Non-point Source	Organic Matter Retention	1	3	3	4	3	1	1
Chemical	Point Source	Agricultural Pesticides	1	2	2	3	3	0	1
Chemical	Point Source	Dissolved Oxygen	2	3	4	2	3	1	2
Chemical	Point Source	Industrial (NPDES)	1	2	3	3	3	0	1
Chemical	Point Source	Pathogens/ Endocrine disruptors	5	3	4	2	3	1	5
Future Changes		Land Conversion	5	4	4	5	1	5	4
Future Changes		Sea Level Rise	1	2	5	5	1	2	1
Habitat Alteration		Channelization	2	2	3	3	2	1	1
Habitat Alteration		Forest Fragmentation	2	3	2	3	2	1	1
Habitat Alteration		Ground Water withdrawal	1	2	2	2	3	0	1
Habitat Alteration		Migration Barriers	1	2	3	3	2	1	1
Habitat Alteration		Runoff/ baseflow/ down cutting	1	3	3	4	2	1	1
Habitat Alteration		Sedimentation	0	3	3	4	3	0	0
Habitat Alteration		Surface water withdrawal	0	2	2	2	3	0	0
Habitat Alteration		Wetland Loss	2	3	3	4	2	1	1
Non-natives		Invasive plants (riparian)	3	3	2	3	2	1	2
Non-natives		Non-native species (aquatic)	3	2	2	3	2	1	2

Legend for Appendix D.

EXTENT (0-5) Based on the estimated percentage of stream miles or, in some cases, area in the watershed that are affected
0 = None or negligible
1 = 1-10%
2 = 11-20%
3 = 21-30%
4 = 31- 60%
5 = 61-100%

TREND (1-5) Based on the projected rate of change and immediacy of the impact
0 = Threat extent deceasing over time, either due to human intervention or natural rejuvenation
1 = Threat extent unchanging
2 = Threat slowly getting worse; up to 0.25% change per year
3 = Threat extent is getting worse; up to 0.5% change per year
4 = Threat extent is steadily growing, up to 2% change per year
5 = Threat extent is rapidly growing, 2 or more percent per year

SEVERITY (0-5) Based on the estimated or known impact to aquatic ecosystems.
0 = No impact likely
1 = Mild
2 = Moderate; degradation of some forms of biological function; detectable shift in community structure & species loss
3 = Serious; significant loss of biological function, communities often dominated by tolerant generalists &/or richness declines
4 = Very serious; heavy loss of biological function; only tolerant species remain
5 = Catastrophic; near-total loss of biological function in affected areas

PERSISTANCE (1-5) Based on duration of impact
0 = Recovery nearly immediate
1 = Short duration, substantial recovery possible in less than 1 year
2 = Moderate duration, substantial recovery possible within 5 years
3 = Long duration, substantial recovery possible within 5-50 years with human remediation
4 = Extreme duration, substantial recovery not likely for 50 to 100s of years, even with intensive human intervention
5 = Essentially permanent environmental feature lasting hundreds of years, even with intensive human intervention

REVERSIBILITY (1-5) Based on the degree of difficulty to reduce or eliminate the threat
1 = Only correctable using extreme or unproven measures and at extreme relative cost
2 = Mostly correctable, but at very high socioeconomic cost
3 = Correctable using existing technology, but at high relative cost (social or economic)
4 = Correctable with existing technology and moderate cost
5 = readily remedied using existing technology

PREVENTION RANK

((TREND + SEVERITY + PERSISTENCE) X EXTENT / REVERSIBILITY) + EXTENT = PREVENTION RANK

Critical (5). Will almost certainly result in widespread, complete loss of GCN habitat and/or populations within the watershed. Action is imperative.

Serious (4). Will result in widespread and severe degradation of GCN habitat and/or reduction in populations within the watershed. Action is highly important.

Moderate (3). Will contribute to degradation of GCN habitat and/or decline in GCN population levels. Action should be taken.

Low (2). Evidence indicates that without action, a long-term decline in GCN habitat and/or population levels is probable due to the cumulative effect of this and other threats. A plan for long-term action to eliminate or reduce this threat should be considered to ensure sustainability of GCN habitat/populations.

Slight (1). Evidence indicates that some long-term decline in GCN habitat/populations is possible. Better monitoring of this threat should be considered.

None (0). Available information in this watershed indicates little or no need for action.

RESTORATION RANK

(REVERSIBILITY + SEVERITY) = RESTORATION RANK

Critical (5). Will almost certainly result in widespread, complete loss of GCN habitat and/or populations within the watershed. Action is imperative.

Serious (4). Will result in widespread and severe degradation of GCN habitat and/or reduction in populations within the watershed. Action is highly important.

Moderate (3). Will contribute to degradation of GCN habitat and/or decline in GCN population levels. Action should be taken.

Low (2). Evidence indicates that without action, a long-term decline in GCN habitat and/or population levels is probable due to the cumulative effect of this and other threats. A plan for long-term action to eliminate or reduce this threat should be considered to ensure sustainability of GCN habitat/populations.

Slight (1). Evidence indicates that some long-term decline in GCN habitat/populations is possible. Better monitoring of this threat should be considered.

None (0). Available information in this watershed indicates little or no need for action.